

- Chemical risk drivers: none
- Chemical hazard drivers: chromium, nitrate, and total uranium

The COPC drivers for Tank Closure Alternative 4 were selected by evaluating the risk or hazard associated with all 19 COPCs during the year of peak risk or hazard at the Core Zone Boundary during the 10,000-year period of analysis and selecting the major contributors. This process is described in Appendix Q. Uranium-238 and total uranium were added to the COPC drivers; although their contributions to risk and hazard are not dominant during the year of peak risk or hazard, they become major contributors toward the end of the period of analysis. The radiological risk drivers account for essentially 100 percent of the radiological risk. No chemical risk is predicted. The chemical hazard drivers account for 100 percent of the chemical hazard associated with Tank Closure Alternative 4.

The COPC drivers that are discussed in detail in this section fall into three categories. Iodine-129, technetium-99, chromium, and nitrate are all mobile (i.e., move with groundwater) and long-lived (relative to the 10,000-year period of analysis), or stable. They are essentially conservative tracers. Tritium is also mobile, but short-lived. The half-life of tritium is about 13 years, and tritium concentrations are strongly attenuated by radioactive decay during travel through the vadose zone and groundwater systems. Finally, uranium-238 and total uranium are long-lived, or stable, but are not as mobile as the other COPC drivers. These constituents move about seven times more slowly than groundwater. As the analyses of release, concentration versus time, and spatial distribution of the COPC drivers are presented, the distinct behavior of these three groups will become apparent.

The other COPCs that were analyzed do not significantly contribute to drinking water risk at the Core Zone Boundary during the period of analysis because of limited inventories, high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of these factors.

5.1.1.7.3 Analysis of Release and Mass Balance

This section presents the impacts of Tank Closure Alternative 4 in terms of the total amount of COPCs released to the vadose zone, groundwater, and the Columbia River during the 10,000-year period of analysis. Releases of radionuclides are totaled in curies; chemicals, in kilograms (see Figures 5–121 through 5–126). Three subtotals are plotted, representing releases from cribs and trenches (ditches), past leaks, and other tank farm sources (e.g., tank residuals, ancillary equipment). Note that the release amounts are plotted on a logarithmic scale to facilitate visual comparison of releases that vary over four orders of magnitude within the same series of figures.

Figure 5–121 shows the estimated release to the vadose zone of the radiological risk drivers and Figure 5–122, the chemical hazard drivers. For all three types of sources, the release to the vadose zone is controlled by the inventory (i.e., 100 percent of the inventory is released during the period of analysis). The predominant sources of tritium, chromium, and nitrate are the cribs and trenches (ditches) associated with the B, BX, BY, T, TX, and TY tank farms. For all other COPC drivers, the predominant sources are past leaks. This suggests that activities during the past-practice period are an important impact driver under Tank Closure Alternative 4.

Figure 5–123 shows the estimated release to groundwater of the radiological risk drivers and Figure 5–124, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. For the conservative tracers (iodine-129, technetium-99, chromium, and nitrate), the amount released to groundwater is essentially equal to the amount released to the vadose zone.

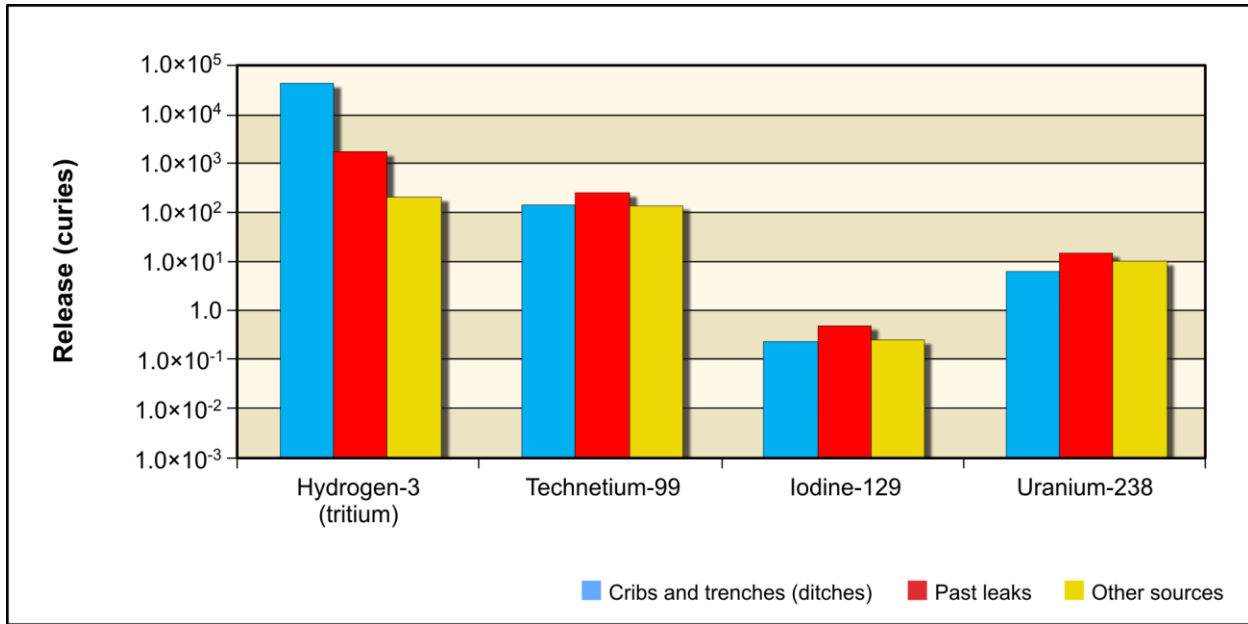


Figure 5–121. Tank Closure Alternative 4 Releases of Radioactive Constituent of Potential Concern Drivers to Vadose Zone for Entire 10,000-Year Analysis Period

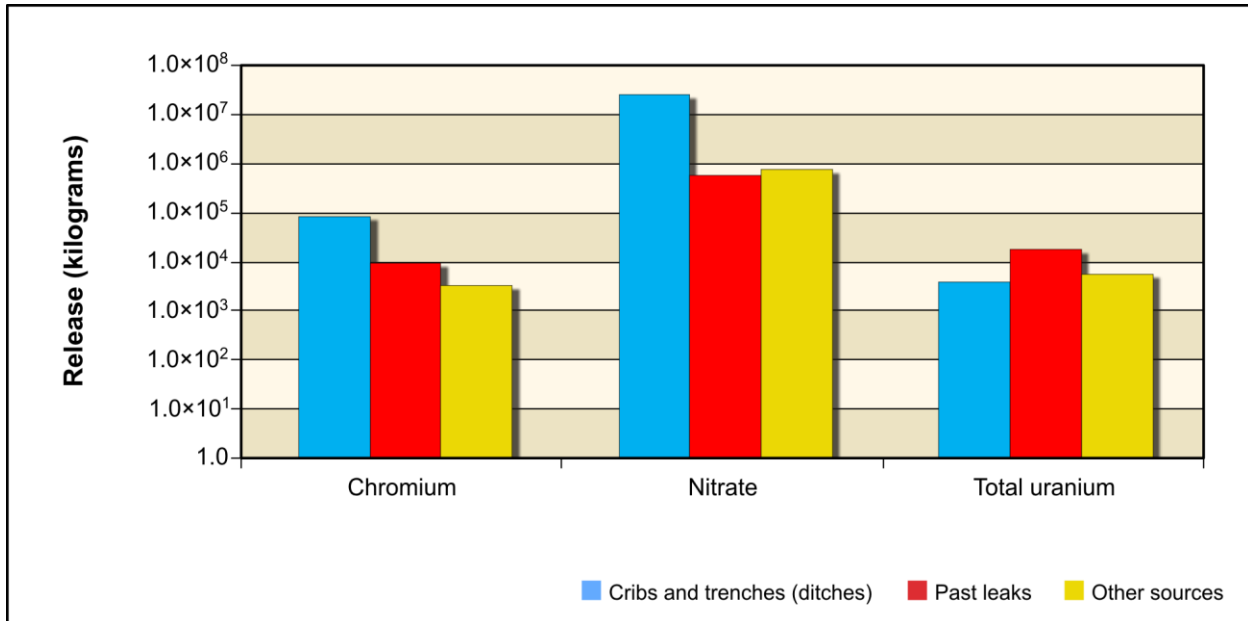


Figure 5–122. Tank Closure Alternative 4 Releases of Chemical Constituent of Potential Concern Drivers to Vadose Zone for Entire 10,000-Year Analysis Period

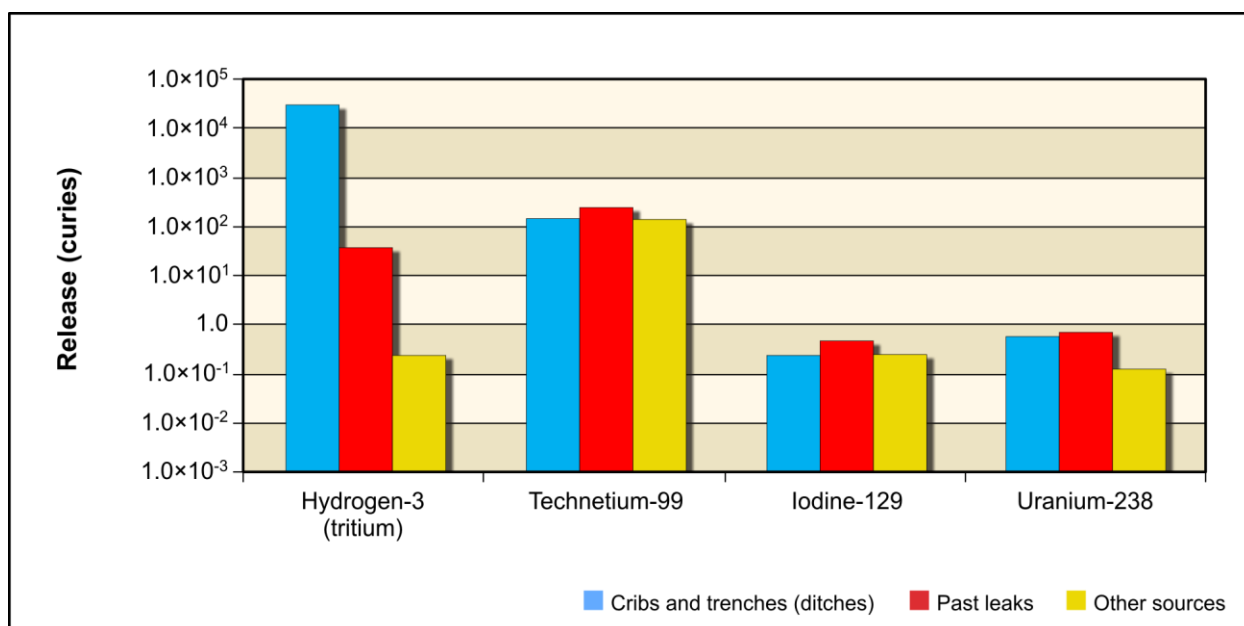


Figure 5–123. Tank Closure Alternative 4 Releases of Radioactive Constituent of Potential Concern Drivers to Groundwater for Entire 10,000-Year Analysis Period

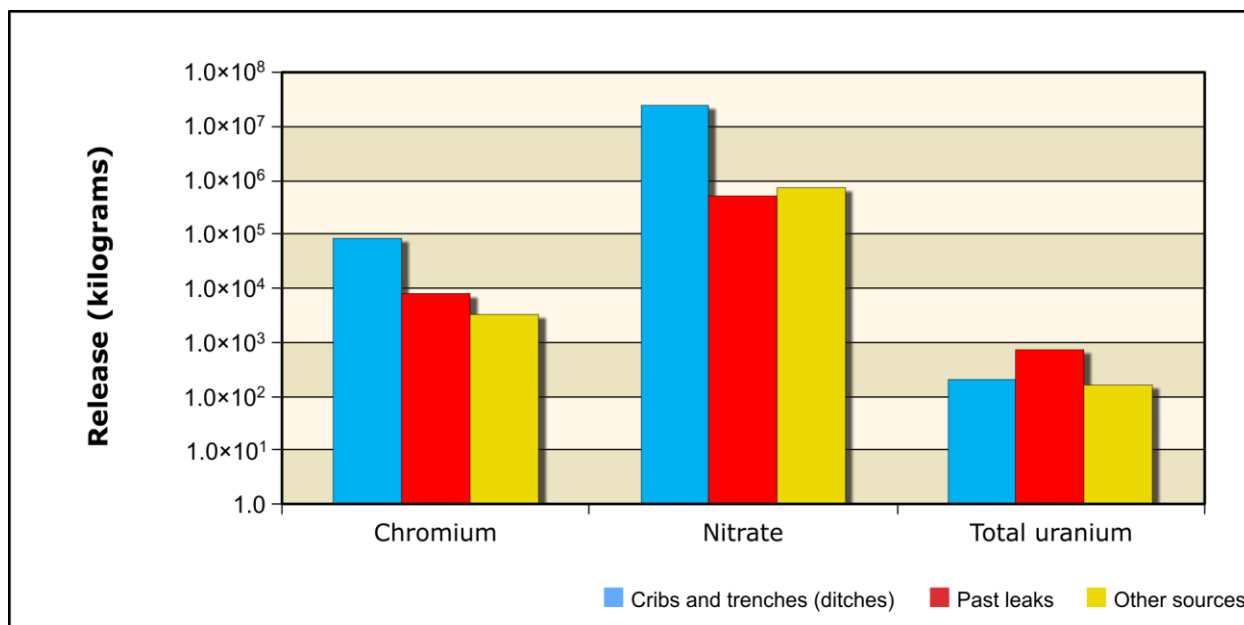


Figure 5–124. Tank Closure Alternative 4 Releases of Chemical Constituent of Potential Concern Drivers to Groundwater for Entire 10,000-Year Analysis Period

For uranium-238 and total uranium, the amount released to groundwater is less than that released to the vadose zone because of vadose zone retention. The amount of this retention depends on the type of contaminant source, specifically volume and timing of moisture movement through the vadose zone. For releases from cribs and trenches (ditches) and past leaks, where moisture movement through the vadose zone is relatively rapid (because of the volume of water associated with the source), about 14 percent of the inventory of uranium-238 and 9 percent of the inventory of total uranium reach groundwater during the period of analysis; for other tank farm sources, only about 1 percent of the uranium-238 and 3 percent of the total uranium inventories reach groundwater during the period of analysis.

For tritium, the amount released to groundwater is attenuated by radioactive decay. For releases from cribs and trenches (ditches), about 70 percent of the total inventory reaches groundwater in the analysis; for past leaks, only 2 percent; and for other tank farm sources, only one-tenth of 1 percent reaches the water table. These results suggest that tritium impacts on groundwater are dominated by releases from cribs and trenches (ditches) and that radioactive decay of tritium is an important attenuation process. They also suggest that uranium-238 and total uranium impacts on groundwater would occur later in the post-administrative control period because of the long travel times in the vadose zone for these COPCs.

Figure 5–125 shows the estimated release to the Columbia River of the radiological risk drivers and Figure 5–126, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. For the conservative tracers (iodine-129, technetium-99, chromium, and nitrate), the amount released to the Columbia River is essentially equal to the amount released to groundwater. For uranium-238 and total uranium, the amount released to the Columbia River is less than that released to groundwater because of retardation. Overall, about 30 percent of the uranium-238 and 27 percent of the total uranium released to groundwater during the period of analysis reach the Columbia River. For tritium, the amount released to the Columbia River is attenuated by radioactive decay. Overall, only about 1 percent of the tritium released to groundwater reaches the Columbia River during the period of analysis. These results suggest that tritium impacts on the Columbia River are strongly attenuated by radioactive decay. They also suggest that uranium-238 and total uranium impacts on the Columbia River would occur later in the post-administrative control period because of the long travel times in the vadose zone and through the groundwater system for these COPCs.

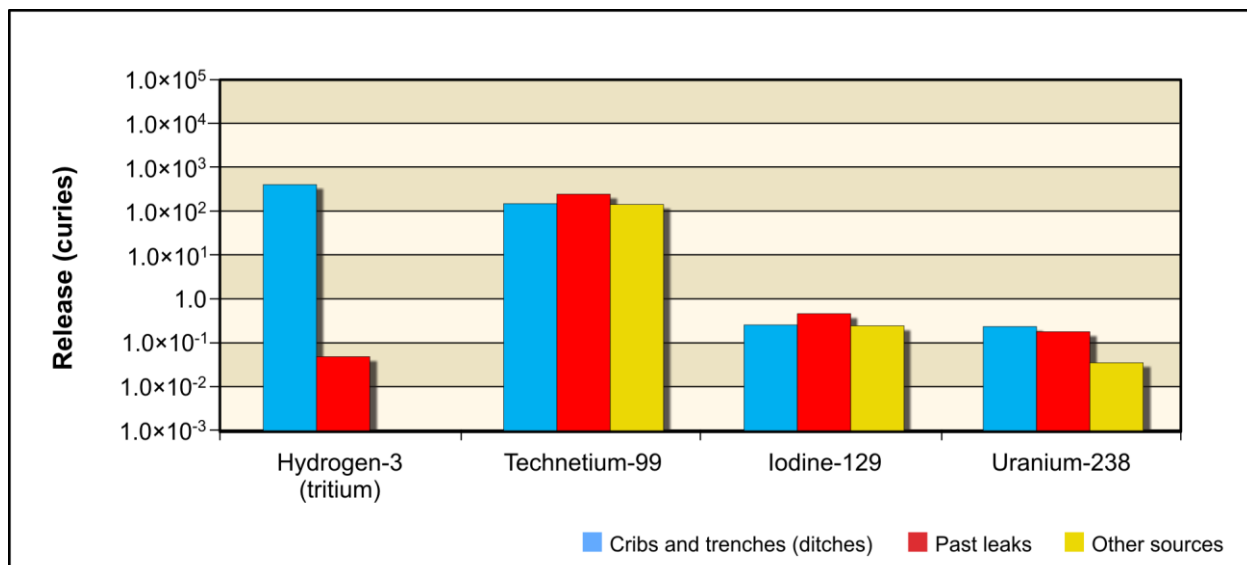


Figure 5–125. Tank Closure Alternative 4 Releases of Radioactive Constituent of Potential Concern Drivers to Columbia River for Entire 10,000-Year Analysis Period

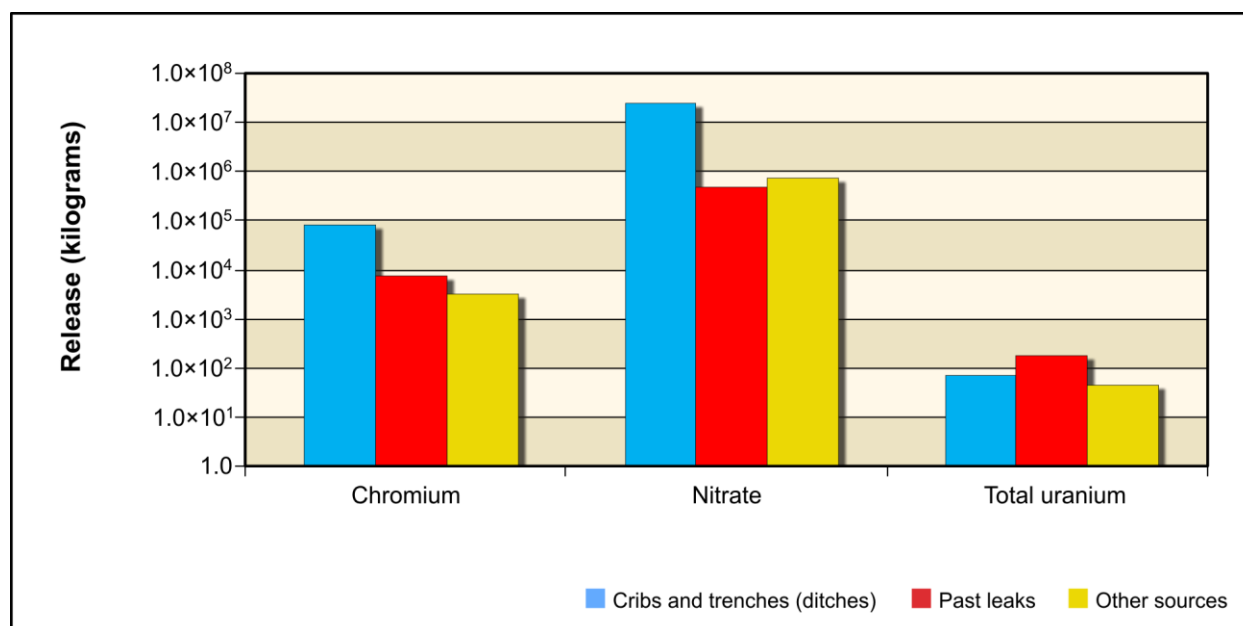


Figure 5–126. Tank Closure Alternative 4 Releases of Chemical Constituent of Potential Concern Drivers to Columbia River for Entire 10,000-Year Analysis Period

5.1.1.7.4 Analysis of Concentration Versus Time

This section presents the analysis of Tank Closure Alternative 4 impacts in terms of groundwater concentration versus time at the Core Zone Boundary and the Columbia River nearshore. Concentrations of radionuclides are in picocuries per liter; chemicals, in micrograms per liter (see Table 5–10 and Figures 5–127 through 5–133). The benchmark concentration of each radionuclide and chemical is also shown. Note that the concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations that vary over five orders of magnitude. Table 5–10 lists the maximum concentrations of the COPCs in the peak year after CY 2050 at the tank farm barriers, Core Zone Boundary, and Columbia River nearshore. Under Tank Closure Alternative 4, tritium, uranium-238, and total uranium never exceed their benchmark concentrations at any location beyond CY 2050. The highest impact occurs at the B and T Barriers and at the Core Zone Boundary, where concentrations of technetium-99, iodine-129, chromium, and nitrate peak above their benchmark concentration values. At the Columbia River nearshore, none of the COPCs peak above the benchmark concentration after CY 2050.

Figure 5–127 shows concentration versus time for tritium. Releases from cribs and trenches (ditches) cause Core Zone Boundary groundwater concentrations to exceed benchmark concentrations by one to two orders of magnitude for a short period of time during the early part of the period of analysis. This time period is represented by the first series of sharp inflections in the curve for the Core Zone Boundary from approximately CY 1955 until CY 1980. During this time, groundwater concentrations at the Columbia River nearshore approach the benchmark concentration. Because the half-life of tritium is less than 13 years, radioactive decay rapidly attenuates groundwater concentration, and tritium is essentially not a factor at times later than CY 2050.

Table 5–10. Tank Closure Alternative 4 Maximum COPC Concentrations in the Peak Year at the Tank Farm Barriers, Core Zone Boundary, and Columbia River Nearshore

Contaminant	A Barrier	B Barrier	S Barrier	T Barrier	U Barrier	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide (picocuries per liter)								
Hydrogen-3 (tritium)	7 (2051)	578 (2052)	4 (2050)	2,870 (2050)	15 (2050)	628 (2051)	477 (2051)	20,000
Technetium-99	790 (2100)	3,500 (2056)	196 (2050)	6,600 (2051)	147 (2058)	3,500 (2056)	392 (2254)	900
Iodine-129	1.4 (2102)	4.3 (2056)	0.4 (2050)	12.6 (2050)	0.2 (2072)	4.3 (2056)	0.7 (2240)	1
Uranium isotopes (includes U-233, -234, -235, -238)	0 (11,865)	3 (11,913)	0 (11,932)	2 (11,909)	0 (11,923)	3 (11,913)	0 (11,937)	15
Chemical (micrograms per liter)								
Chromium	71 (2168)	215 (2050)	27 (2059)	353 (2045)	6 (2050)	215 (2050)	71 (2076)	100
Nitrate	17,600 (2172)	171,000 (2055)	965 (2070)	62,100 (2053)	909 (2071)	171,000 (2055)	17,200 (2122)	45,000
Total uranium	0 (11,826)	4 (11,827)	0 (11,810)	1 (11,843)	0 (11,814)	4 (11,827)	0 (11,937)	30

Note: Corresponding calendar years shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.

Key: COPC=constituent of potential concern.

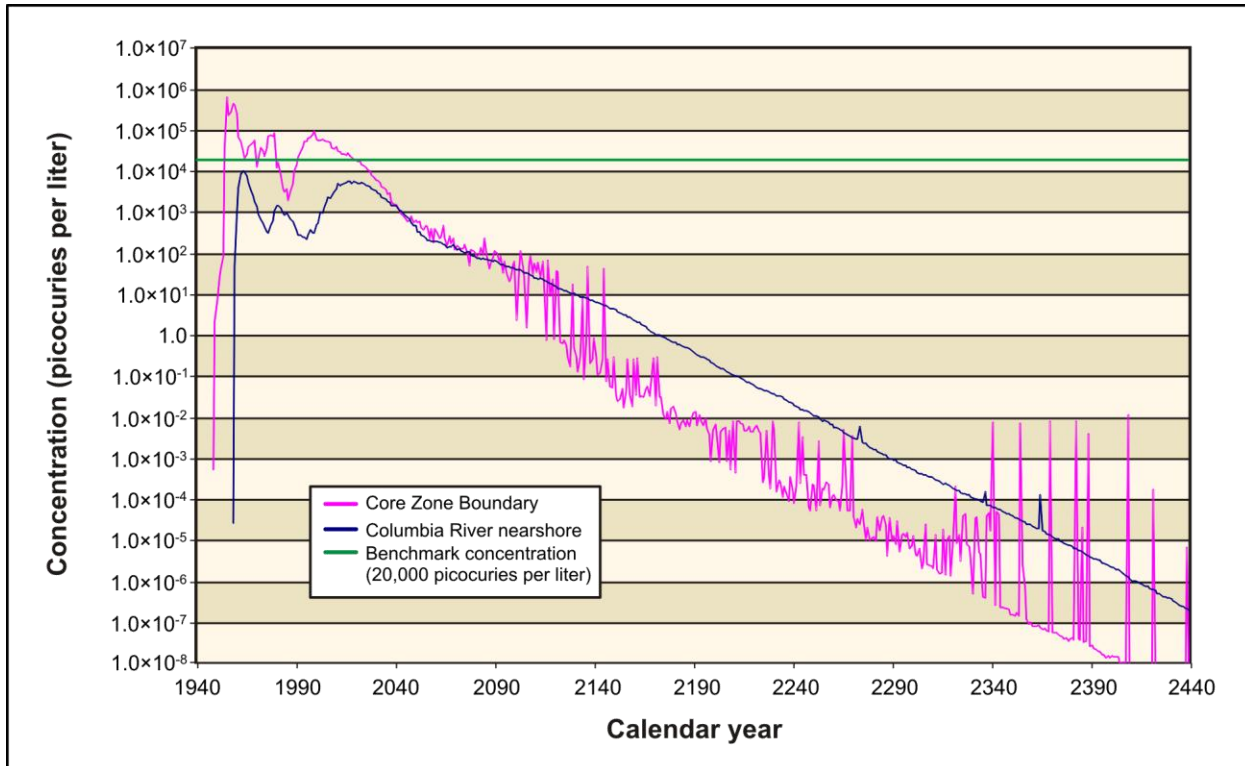


Figure 5–127. Tank Closure Alternative 4 Hydrogen-3 (Tritium) Concentration Versus Time

Figures 5–128 through 5–131 show concentration versus time for iodine-129, technetium-99, chromium, and nitrate (the conservative tracers). Releases from cribs and trenches (ditches) cause groundwater concentrations of iodine-129 to exceed benchmark concentrations by about one to two orders of

magnitude during the early part of the period of analysis at the Core Zone Boundary. This early time period is represented by the multiple sharp inflections in the Core Zone Boundary curve that occur approximately between CY 1955 and CY 1980. The iodine-129 signature also occurs at the Columbia River nearshore at a later time. By about CY 2500, the iodine-129 Core Zone Boundary groundwater concentrations return to levels below the benchmark. Technetium-99, nitrate, and chromium concentrations fall below the benchmark concentration at the Core Zone Boundary around CY 2500. Concentrations of all of the conservative tracers decline over the remainder of the period of analysis.

Figures 5–132 and 5–133 show concentration versus time for uranium-238 and total uranium. Early releases from cribs and trenches (ditches) result in Core Zone Boundary groundwater concentrations that are about two orders of magnitude lower than benchmark concentrations. These concentrations continue to rise throughout the duration of the period of analysis. Uranium-238 and total uranium concentrations come to within an order of magnitude of the benchmark concentration at the Core Zone Boundary near the end of the period of analysis. Groundwater concentrations of uranium-238 and total uranium at the Columbia River nearshore rise throughout the period of analysis but remain over two orders of magnitude below the benchmark concentration for the duration of the simulation.

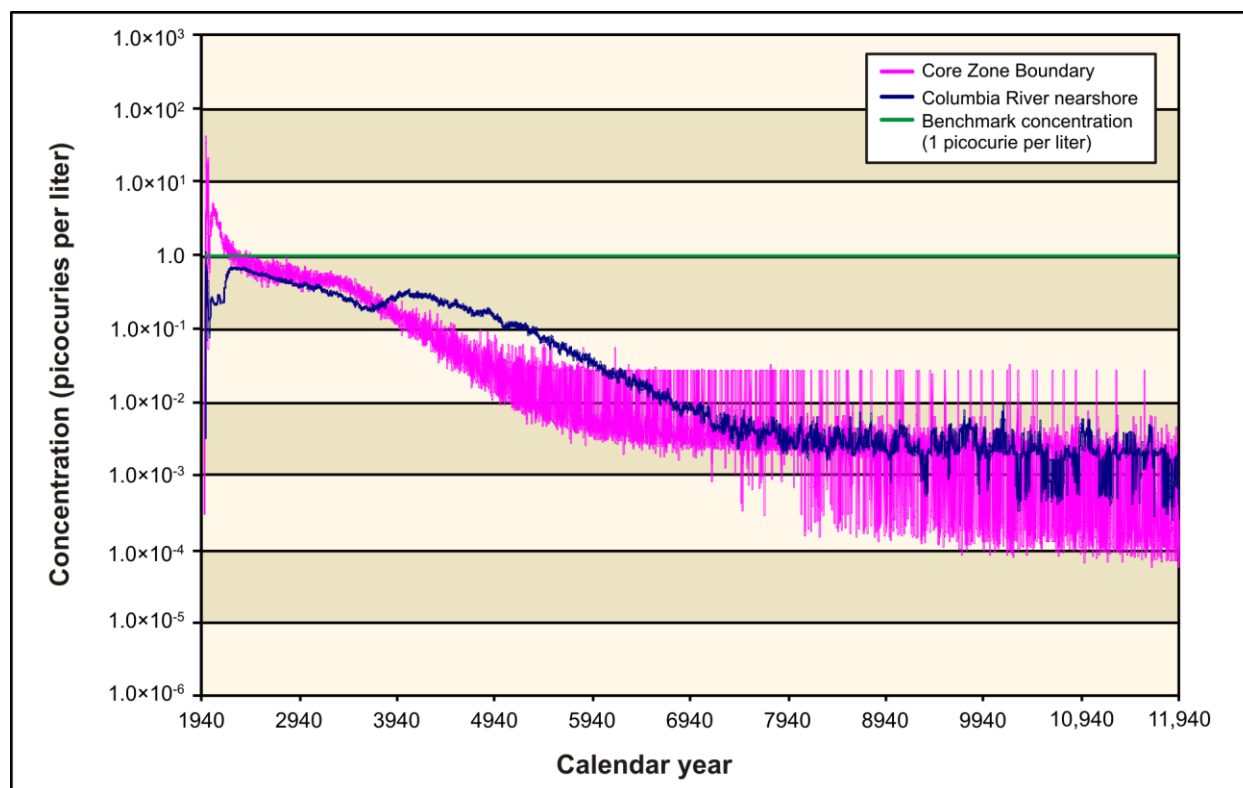


Figure 5–128. Tank Closure Alternative 4 Iodine-129 Concentration Versus Time

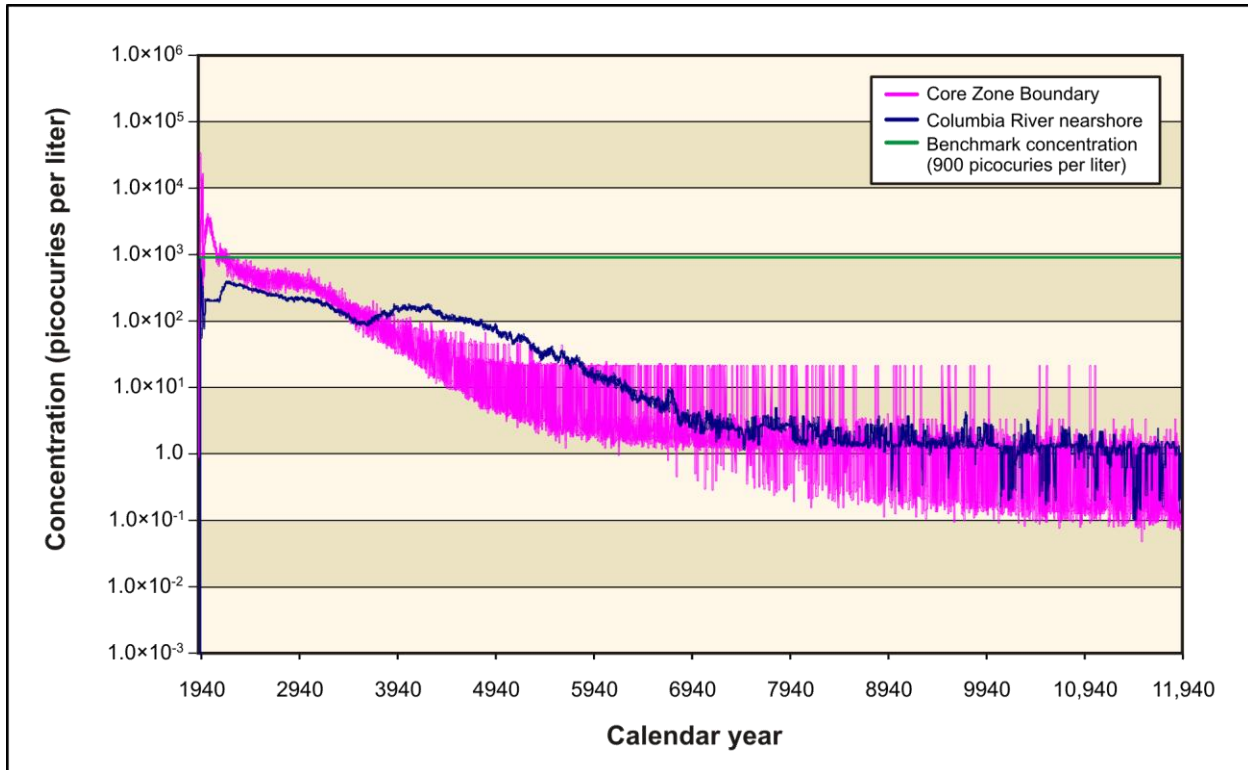


Figure 5-129. Tank Closure Alternative 4 Technetium-99 Concentration Versus Time

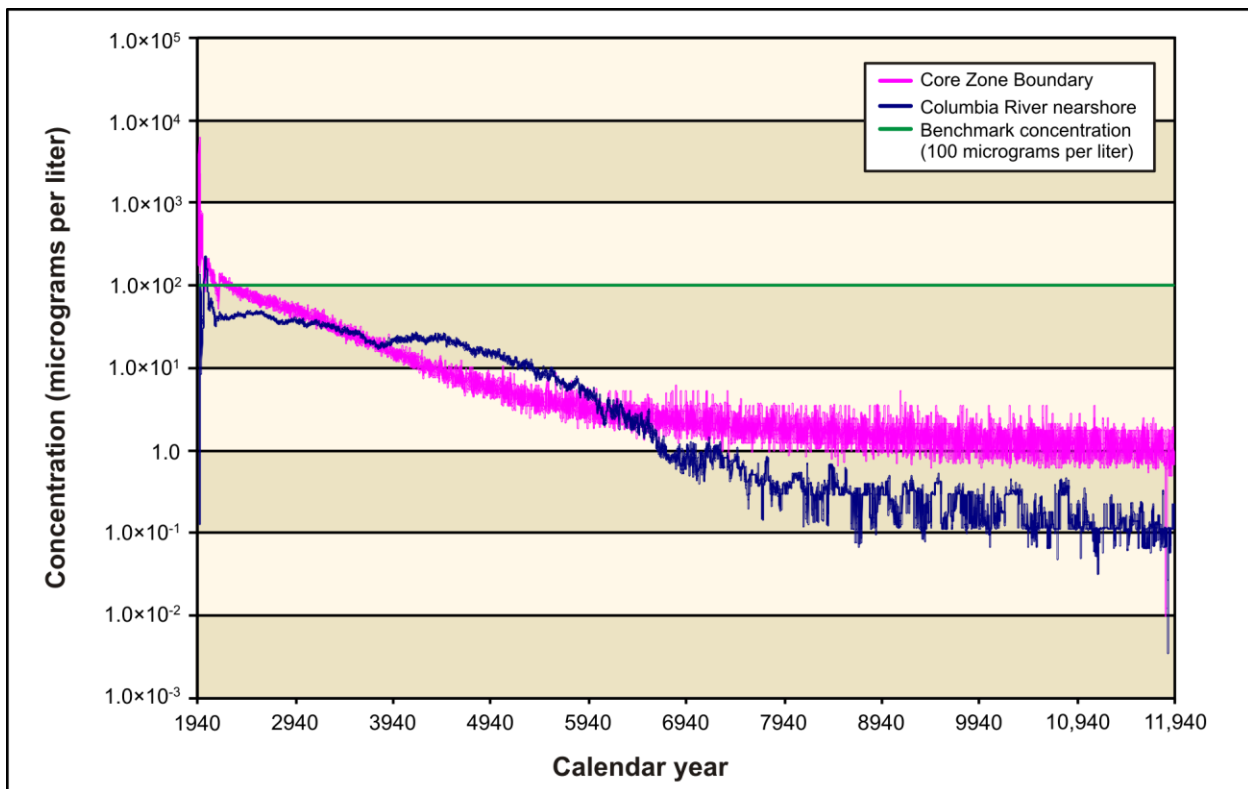


Figure 5-130. Tank Closure Alternative 4 Chromium Concentration Versus Time

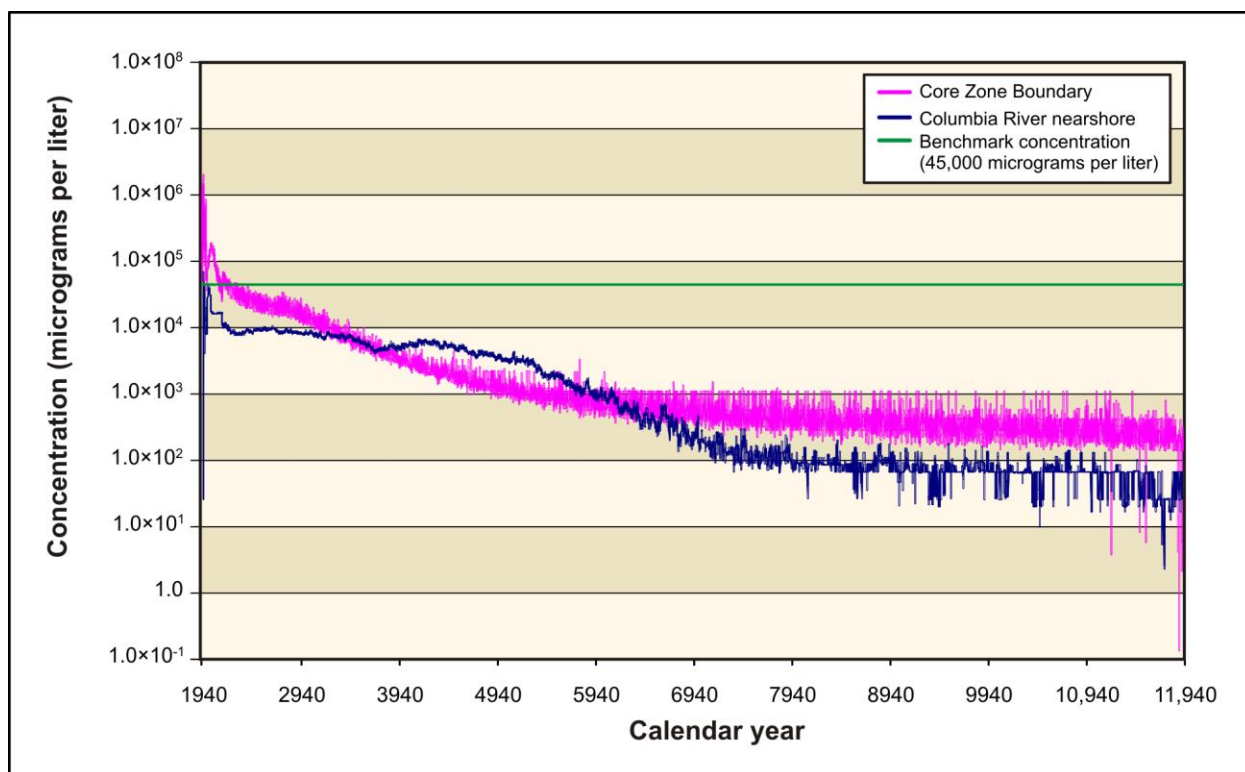


Figure 5-131. Tank Closure Alternative 4 Nitrate Concentration Versus Time

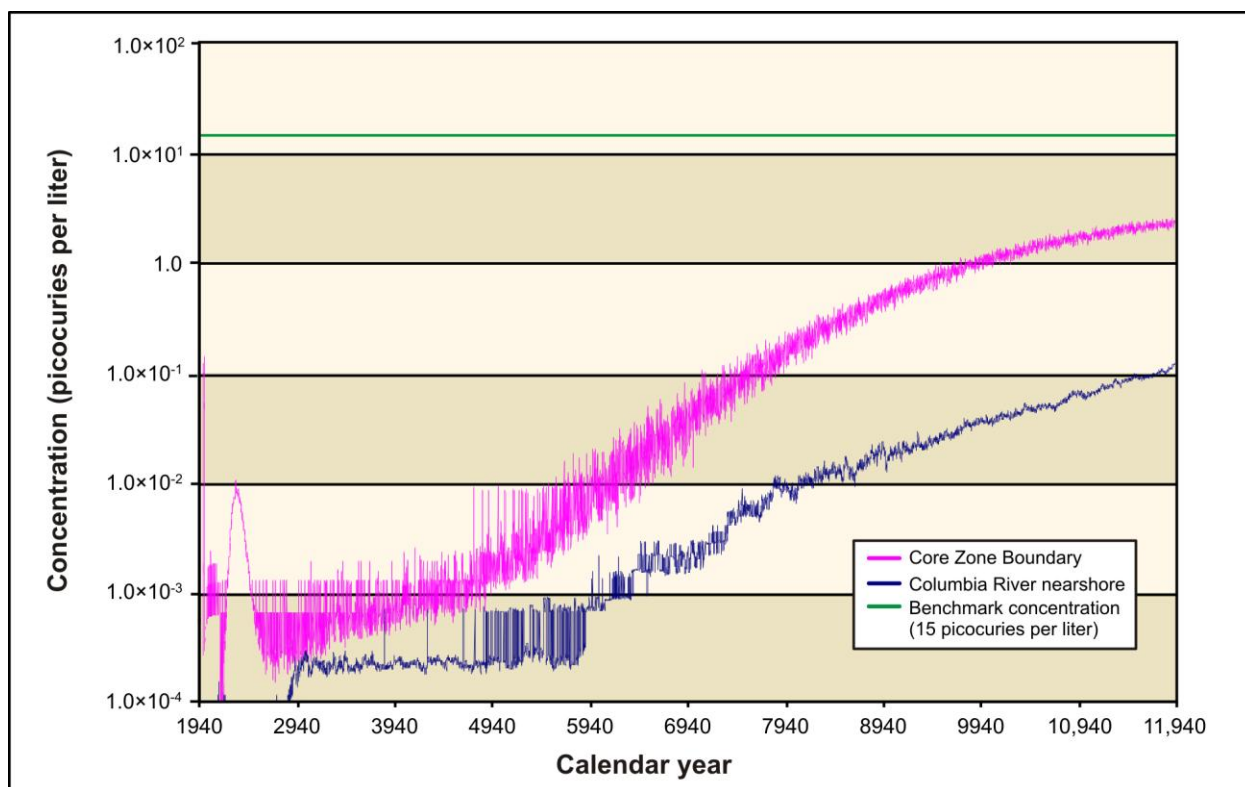


Figure 5-132. Tank Closure Alternative 4 Uranium-238 Concentration Versus Time

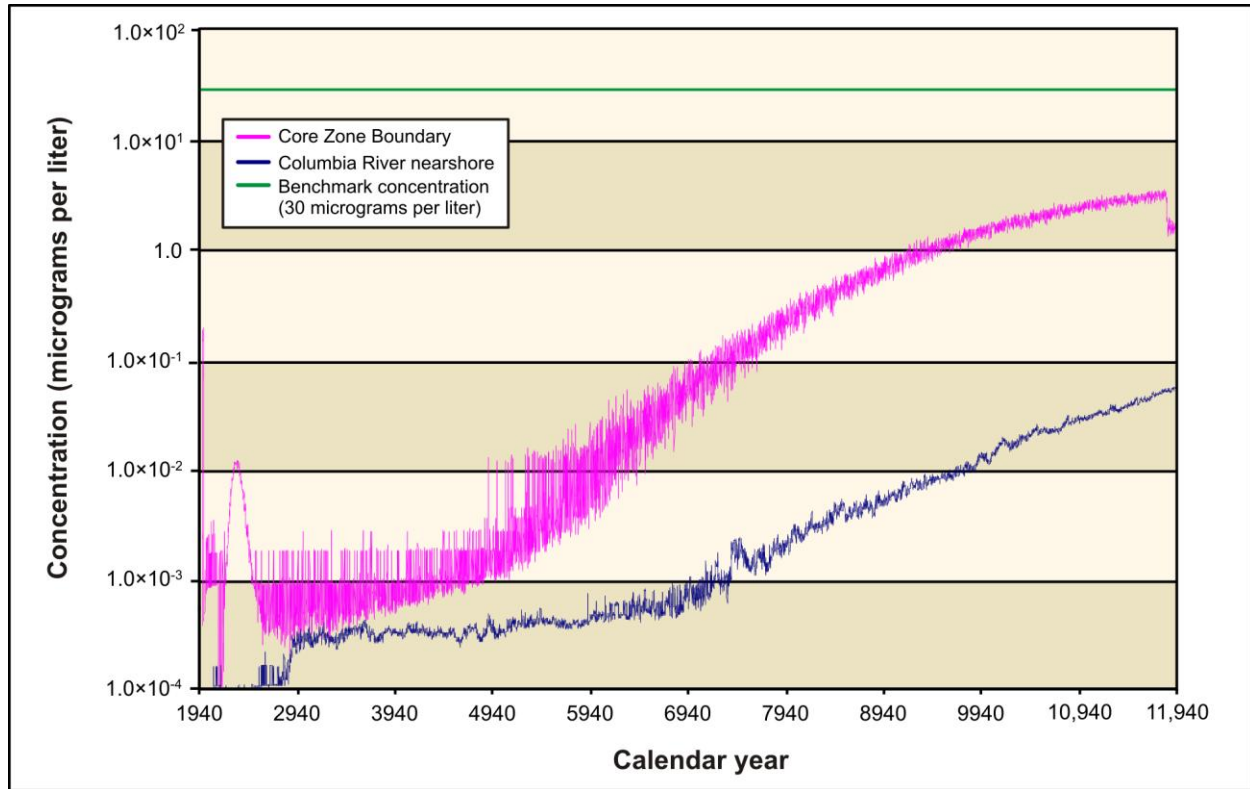
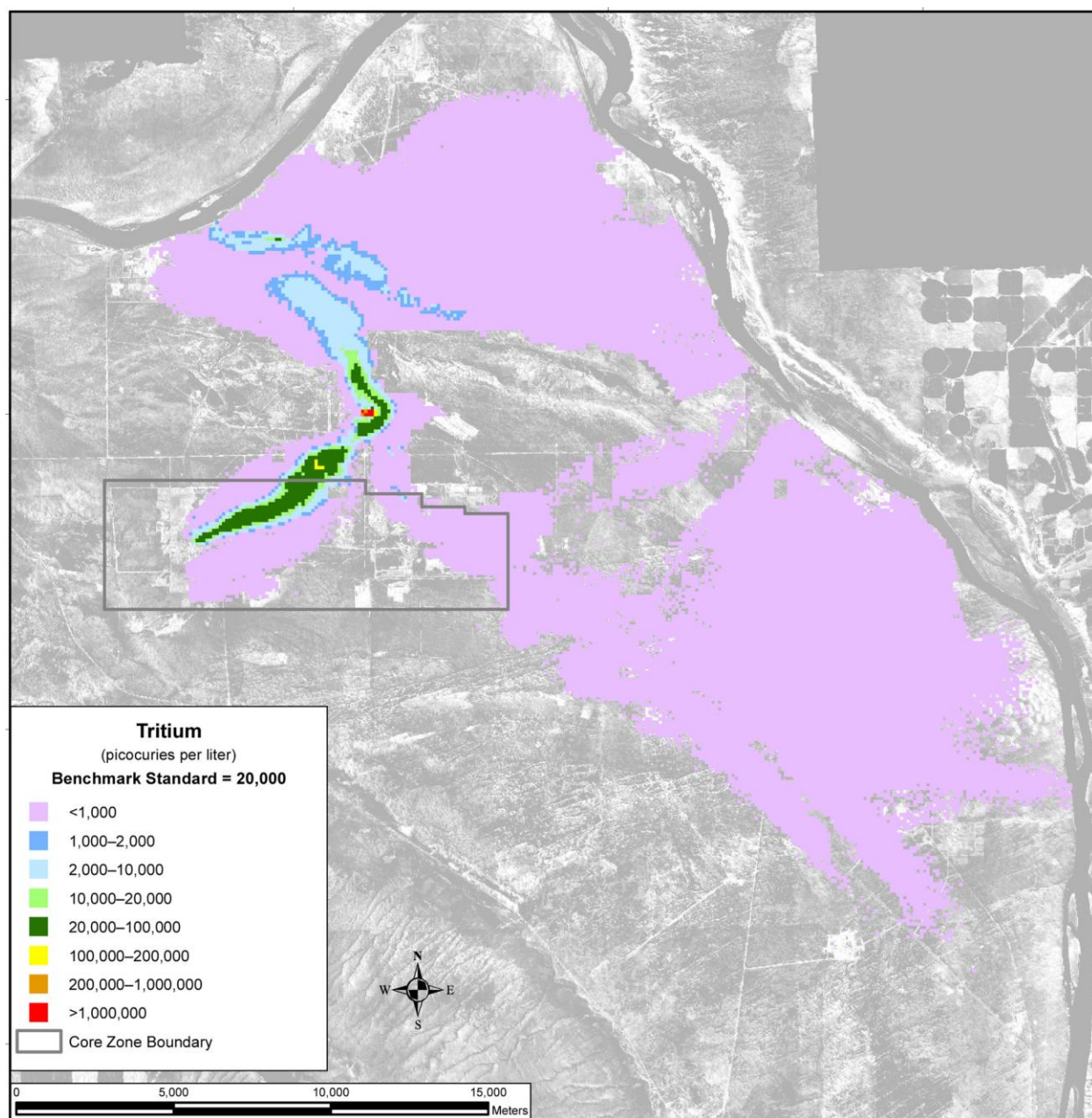


Figure 5-133. Tank Closure Alternative 4 Total Uranium Concentration Versus Time

5.1.1.7.5 Analysis of Spatial Distribution of Concentration

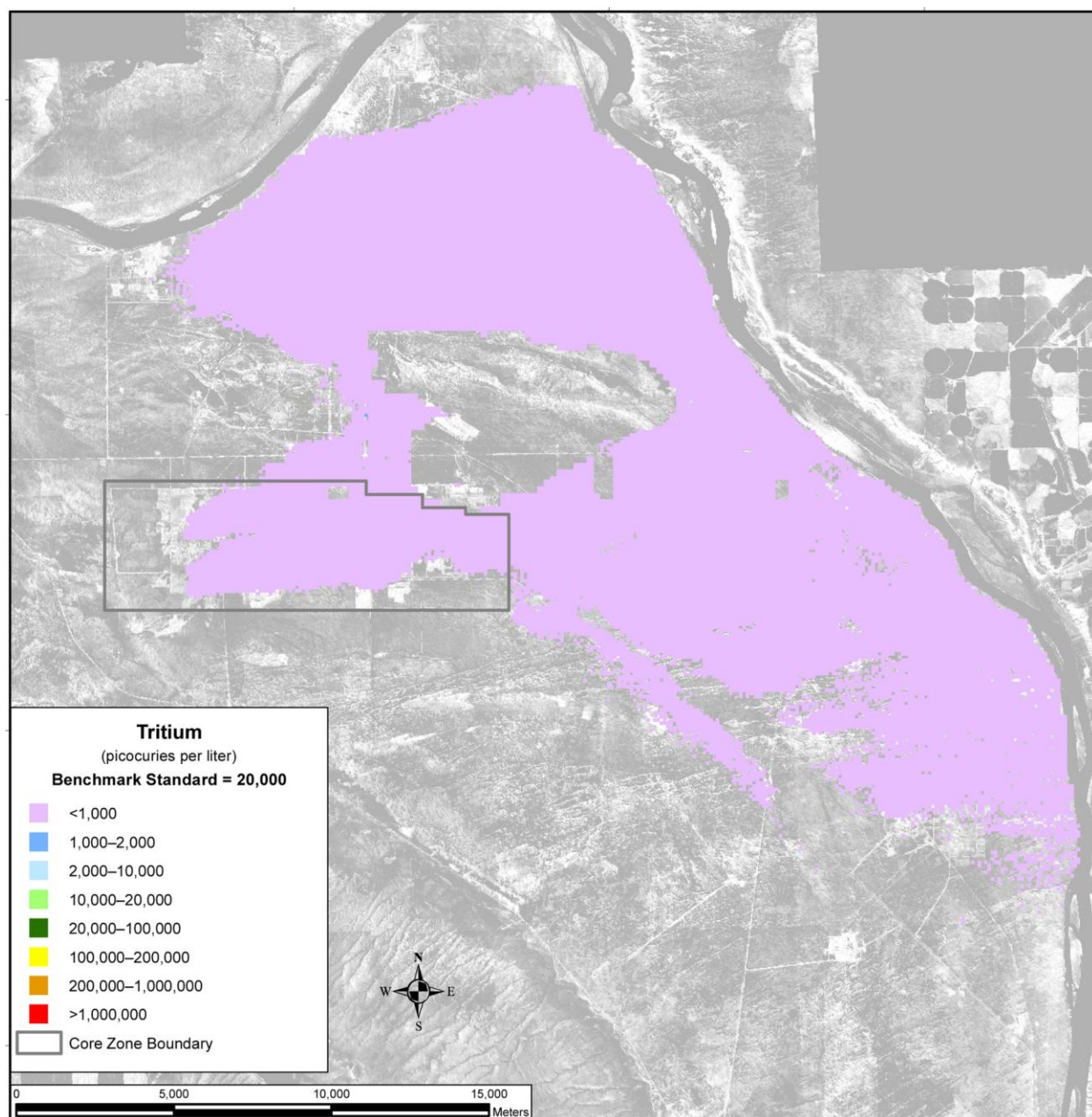
This section presents the impacts of Tank Closure Alternative 4 in terms of the spatial distribution of COPC driver concentrations in groundwater at selected times. Concentrations of radionuclides are in picocuries per liter; chemicals, in micrograms per liter (see Figures 5-134 through 5-155). Concentrations of each radionuclide and chemical are indicated by a color scale that is relative to the benchmark concentration. Concentrations greater than the benchmark concentration are indicated by the fully saturated colors green, yellow, orange, and red in order of increasing concentration. Concentrations less than the benchmark concentration are indicated by the faded colors green, blue, indigo, and violet in order of decreasing concentration. Note that the concentration ranges are on a logarithmic scale to facilitate visual comparison of concentrations that vary over three orders of magnitude.

Figure 5-134 shows the spatial distribution of tritium concentrations in groundwater in CY 2010. Releases from cribs and trenches (ditches) and past leaks, associated primarily with the T, TX, and TY tank farms, result in a groundwater concentration plume (exceeding the benchmark concentration) that extends from the center part of the 200-West Area northeast, crosses the Core Zone Boundary, and continues toward Gable Gap. Peak concentrations in this plume are about 5 to 10 times greater than the benchmark. Tritium concentrations are attenuated by radioactive decay to levels less than one-twentieth of the benchmark concentration by CY 2135 (see Figure 5-135).



Note: To convert meters to feet, multiply by 3.281.

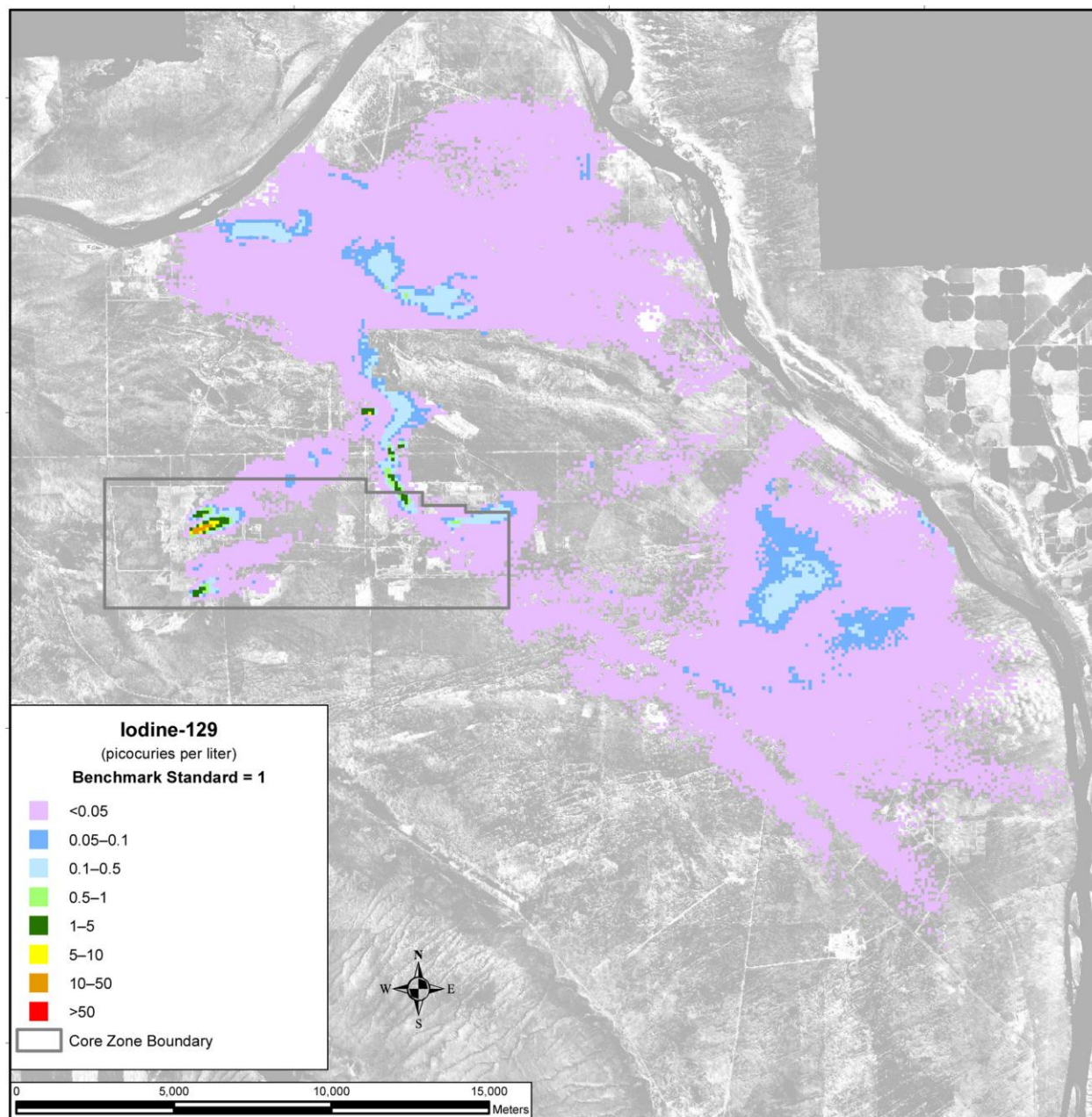
Figure 5–134. Tank Closure Alternative 4 Spatial Distribution of Groundwater Hydrogen-3 (Tritium) Concentration, Calendar Year 2010



**Figure 5–135. Tank Closure Alternative 4 Spatial Distribution of Groundwater
Hydrogen-3 (Tritium) Concentration, Calendar Year 2135**

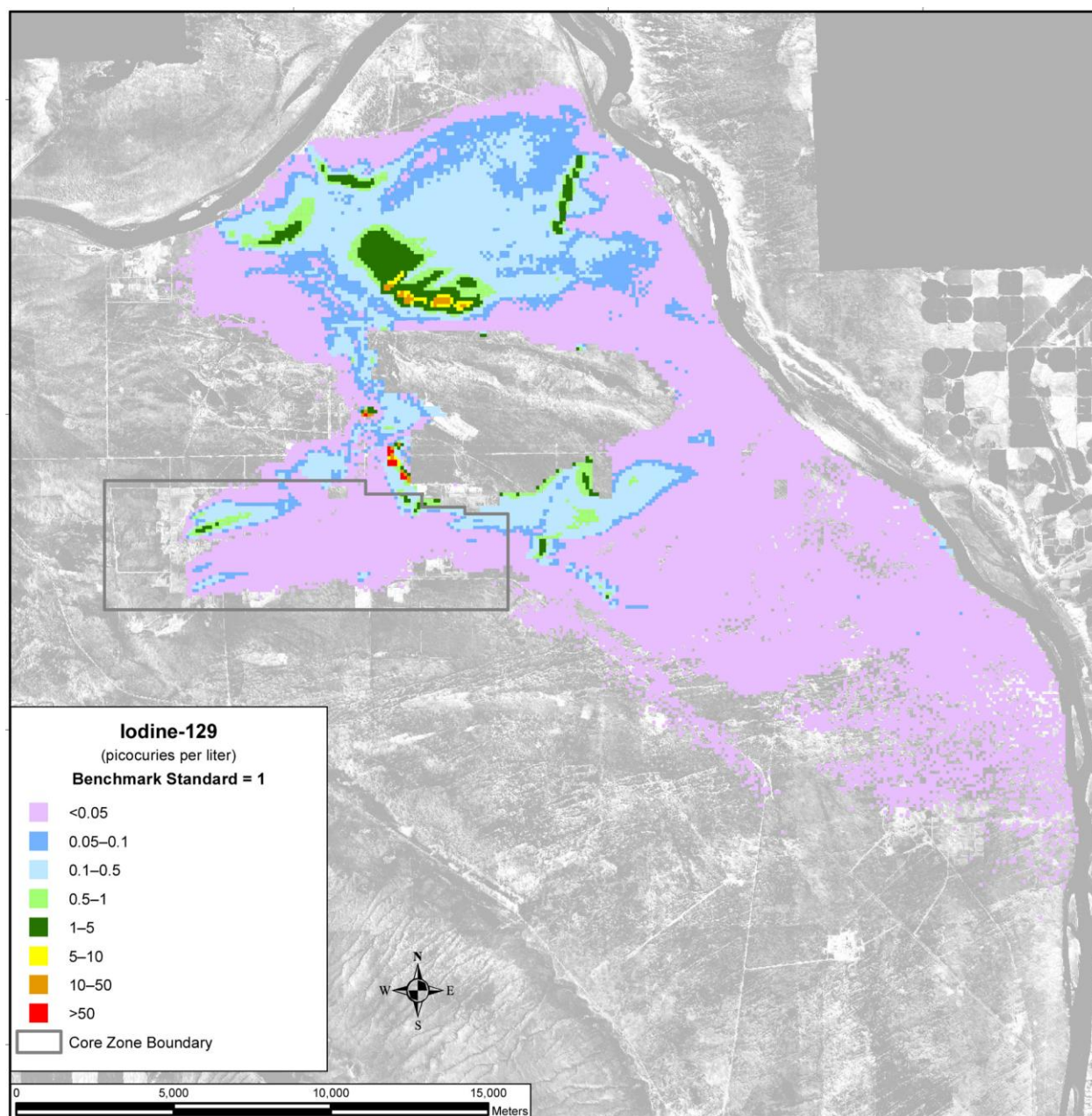
The spatial distribution of iodine-129 concentrations in groundwater in CY 2010 is shown in Figure 5–136. Releases from cribs and trenches (ditches) and past leaks result in groundwater concentration plumes that are at or exceed the benchmark concentration at the B, S, and T Barriers. Peak concentrations in these plumes are about 10 to 50 times greater than the benchmark. By CY 2135 (see Figure 5–137), areas in which groundwater iodine-129 concentrations exceed the benchmark exist mostly in the plume north of Gable Gap. Concentrations are as high as 10 to 50 times greater than the benchmark. By CY 7140, most of the mass in the plume, with concentrations less than one-twentieth of the benchmark, has reached the Columbia River (see Figure 5–138). Technetium-99 (see Figures 5–139 through 5–141), chromium (see Figures 5–142 through 5–144), and nitrate (see Figures 5–145 through

5–147) show similar spatial distributions at selected times. Iodine-129, technetium-99, chromium, and nitrate are all conservative tracers (i.e., move at the rate of the pore-water velocity).

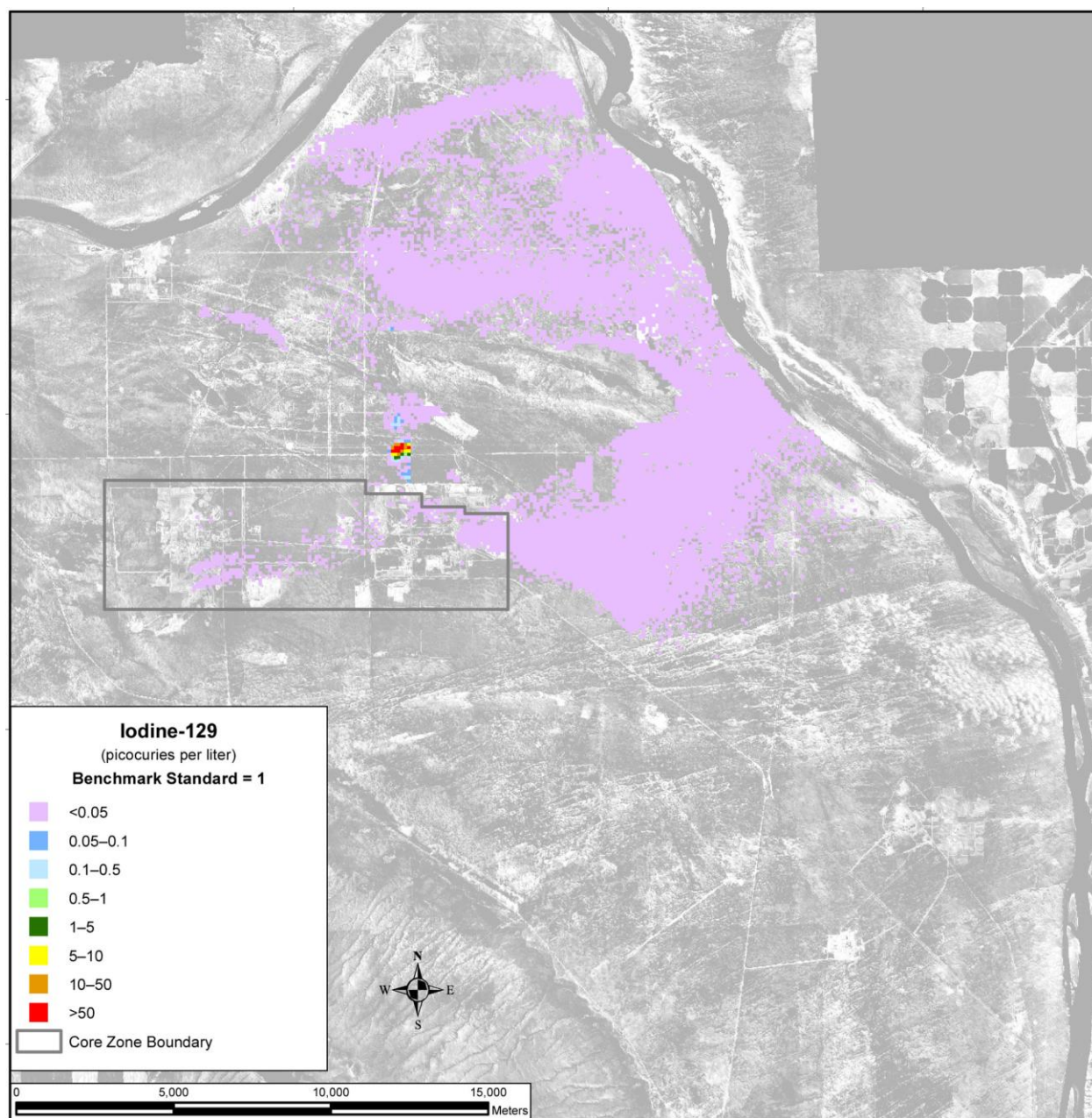


Note: To convert meters to feet, multiply by 3.281.

Figure 5–136. Tank Closure Alternative 4 Spatial Distribution of Groundwater Iodine-129 Concentration, Calendar Year 2010

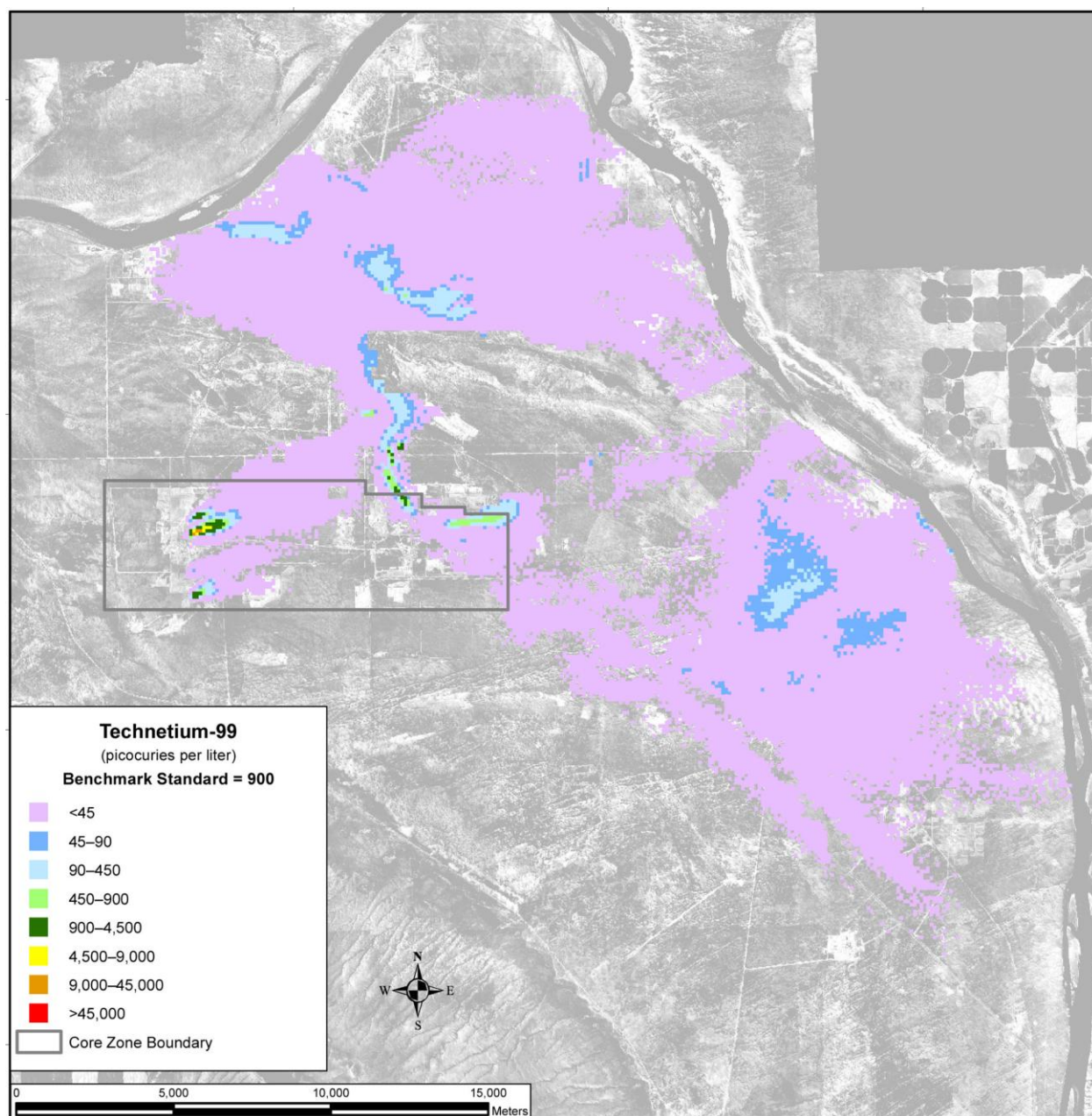


**Figure 5–137. Tank Closure Alternative 4 Spatial Distribution of Groundwater
Iodine-129 Concentration, Calendar Year 2135**

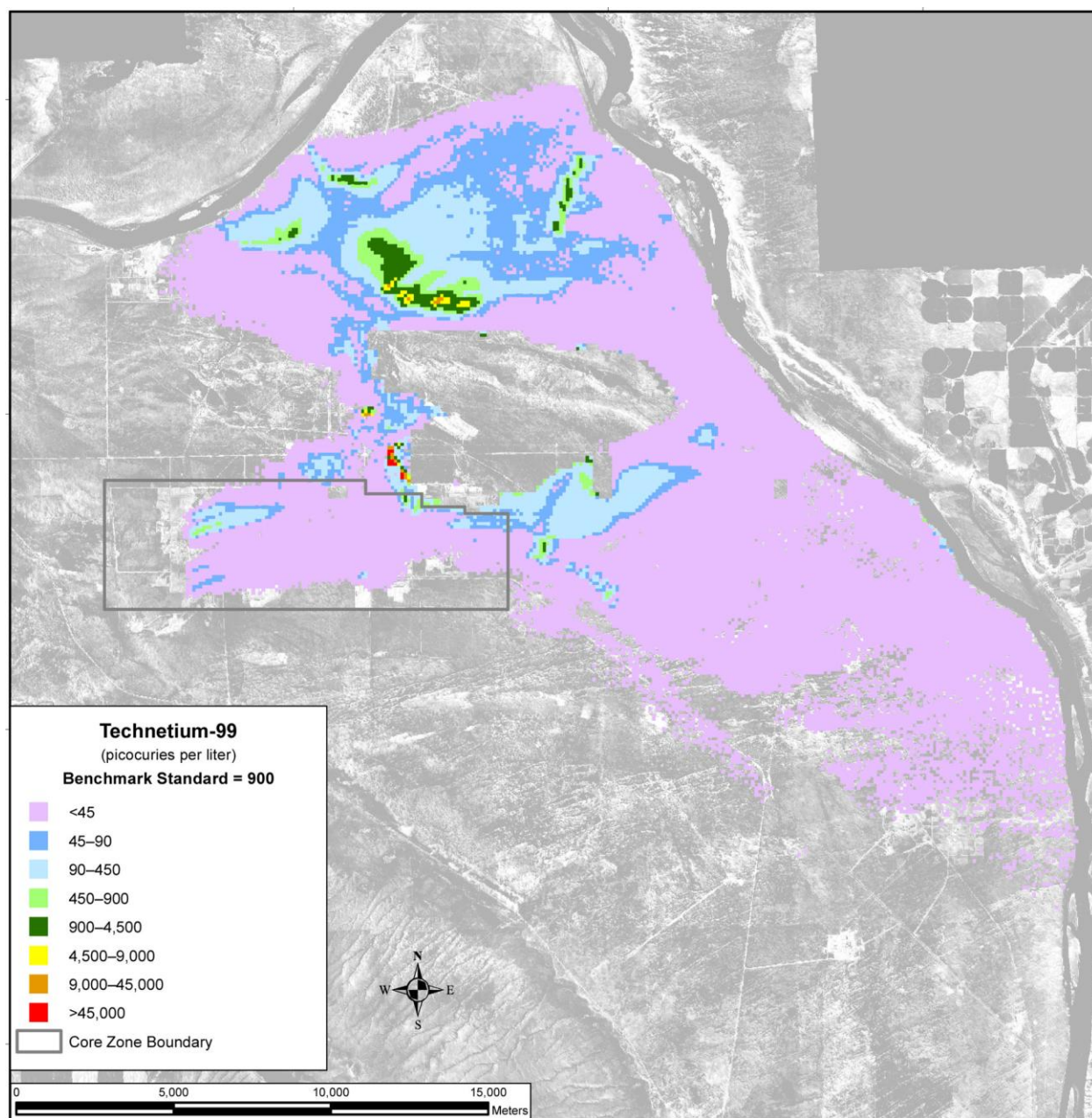


Note: To convert meters to feet, multiply by 3.281.

Figure 5–138. Tank Closure Alternative 4 Spatial Distribution of Groundwater Iodine-129 Concentration, Calendar Year 7140

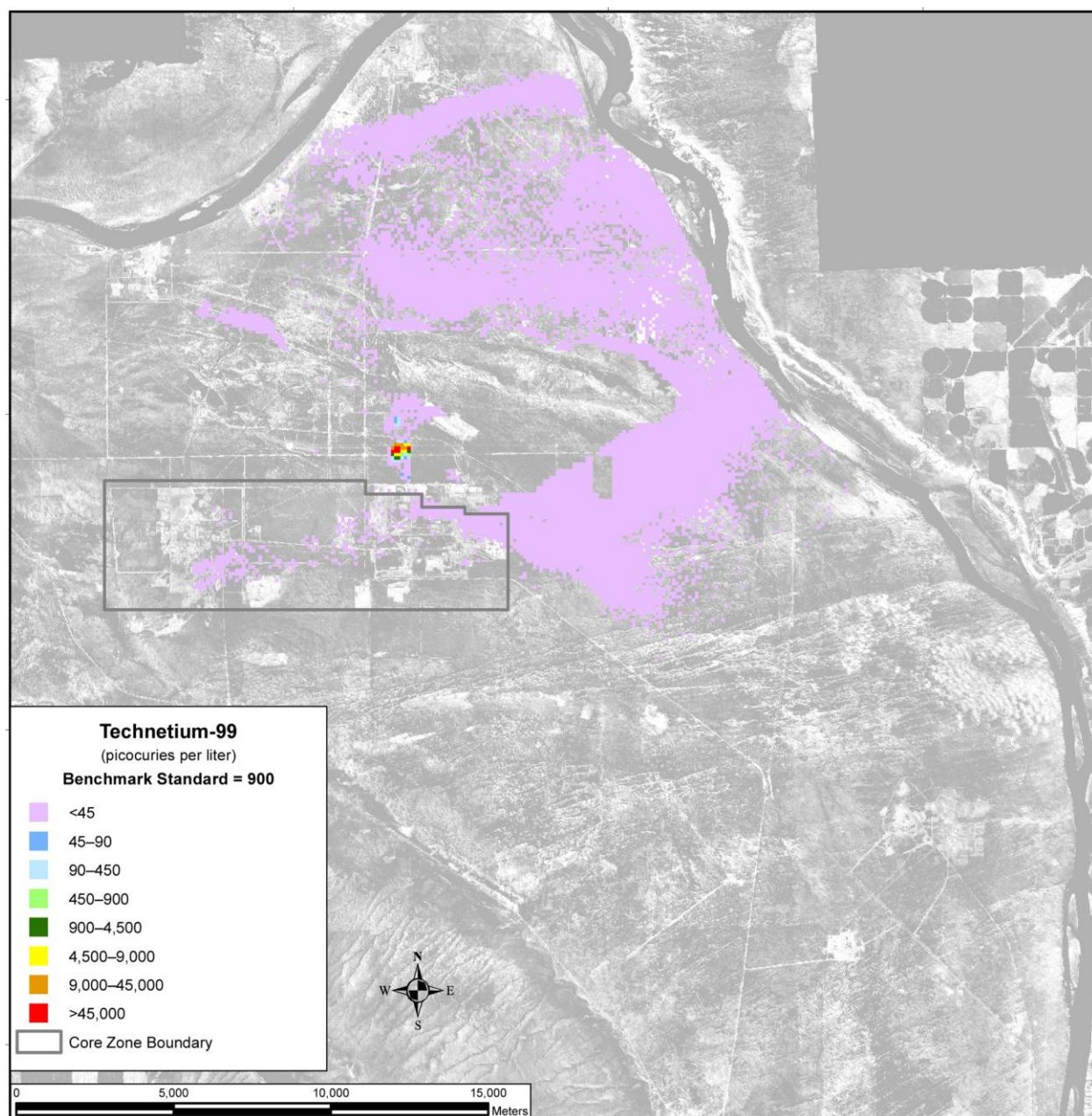


**Figure 5–139. Tank Closure Alternative 4 Spatial Distribution of Groundwater
Technetium-99 Concentration, Calendar Year 2010**

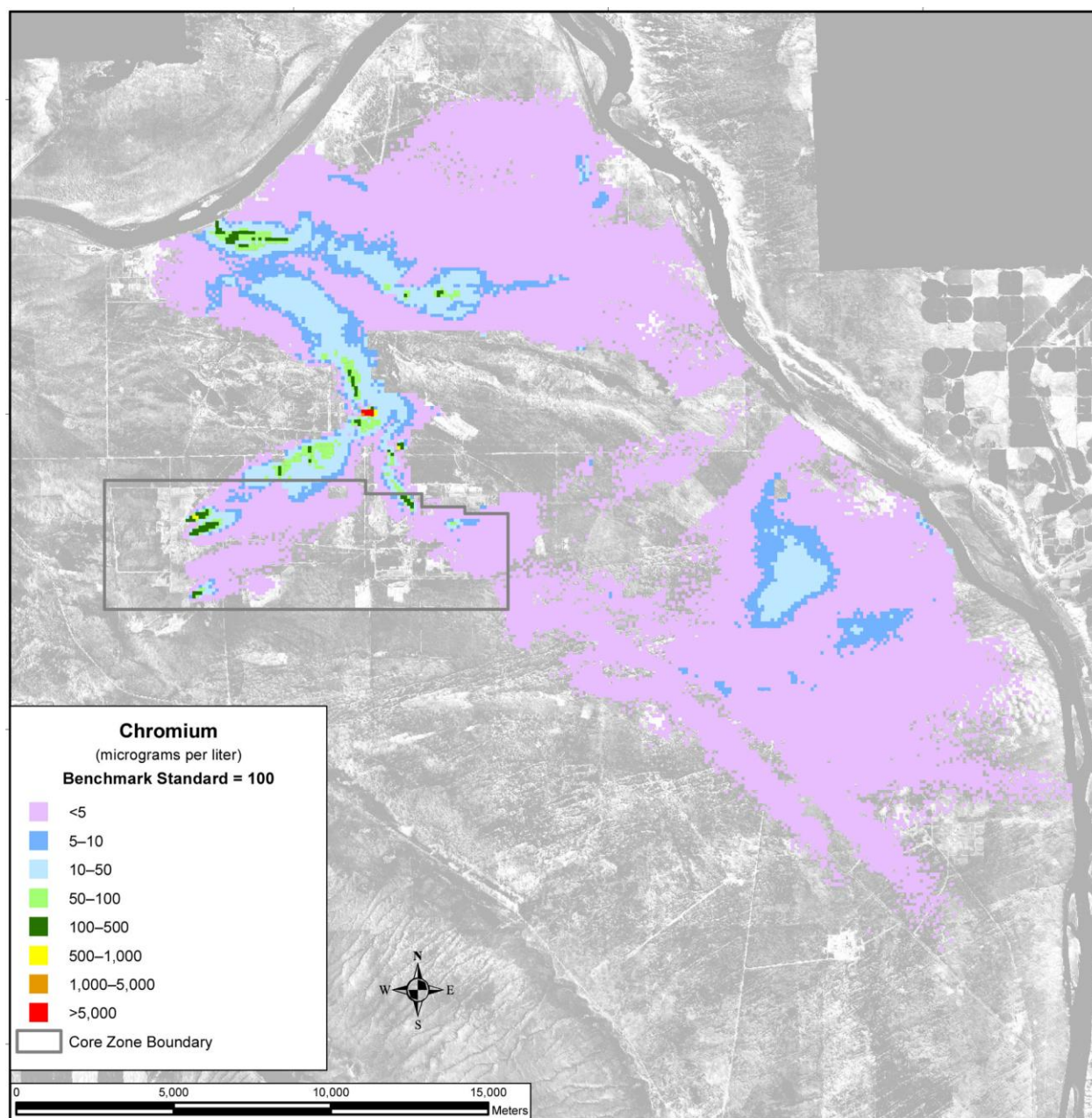


Note: To convert meters to feet, multiply by 3.281.

Figure 5–140. Tank Closure Alternative 4 Spatial Distribution of Groundwater Technetium-99 Concentration, Calendar Year 2135

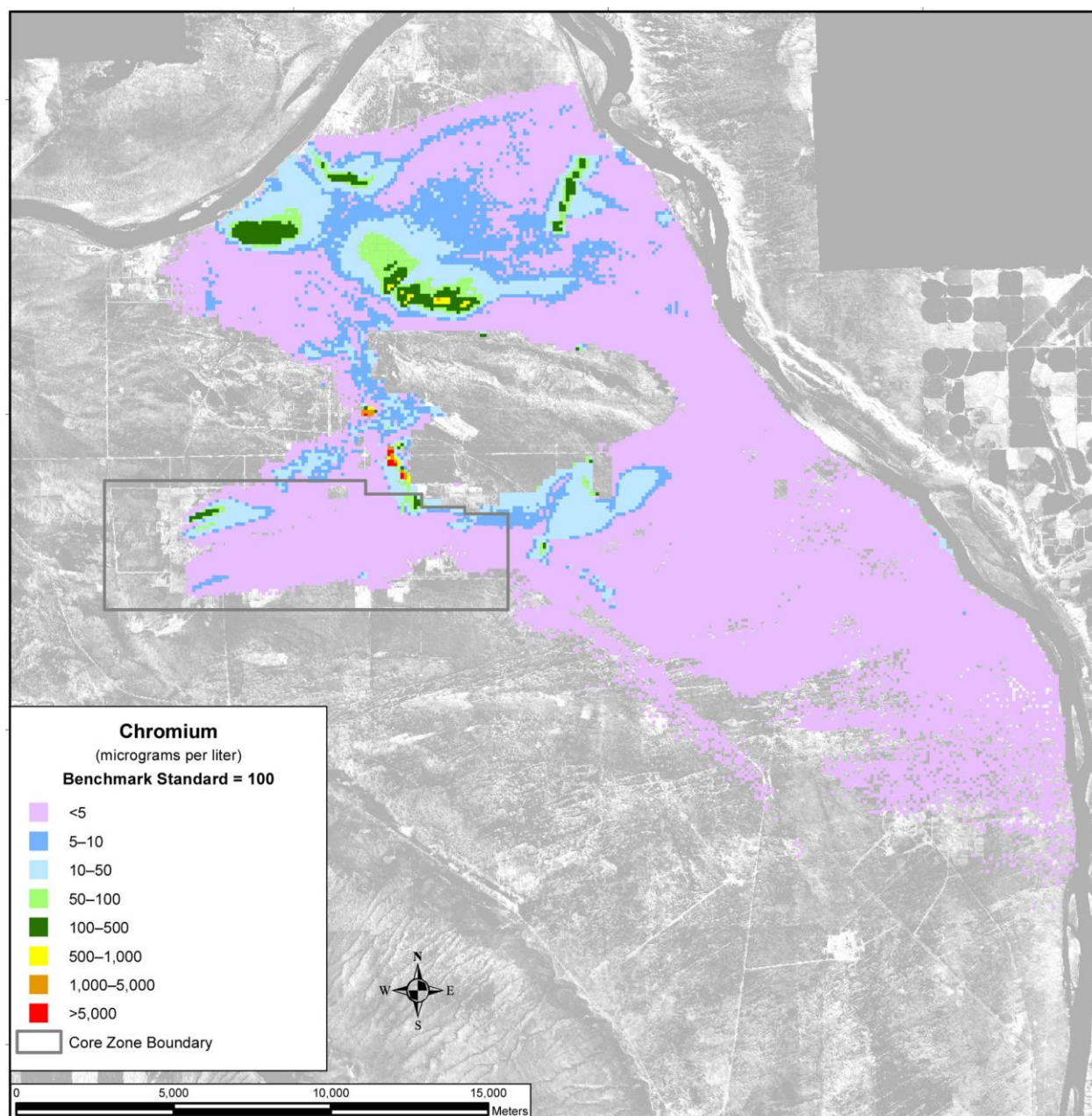


**Figure 5-141. Tank Closure Alternative 4 Spatial Distribution of Groundwater
Technetium-99 Concentration, Calendar Year 7140**



Note: To convert meters to feet, multiply by 3.281.

Figure 5–142. Tank Closure Alternative 4 Spatial Distribution of Groundwater Chromium Concentration, Calendar Year 2010



**Figure 5–143. Tank Closure Alternative 4 Spatial Distribution of Groundwater
Chromium Concentration, Calendar Year 2135**

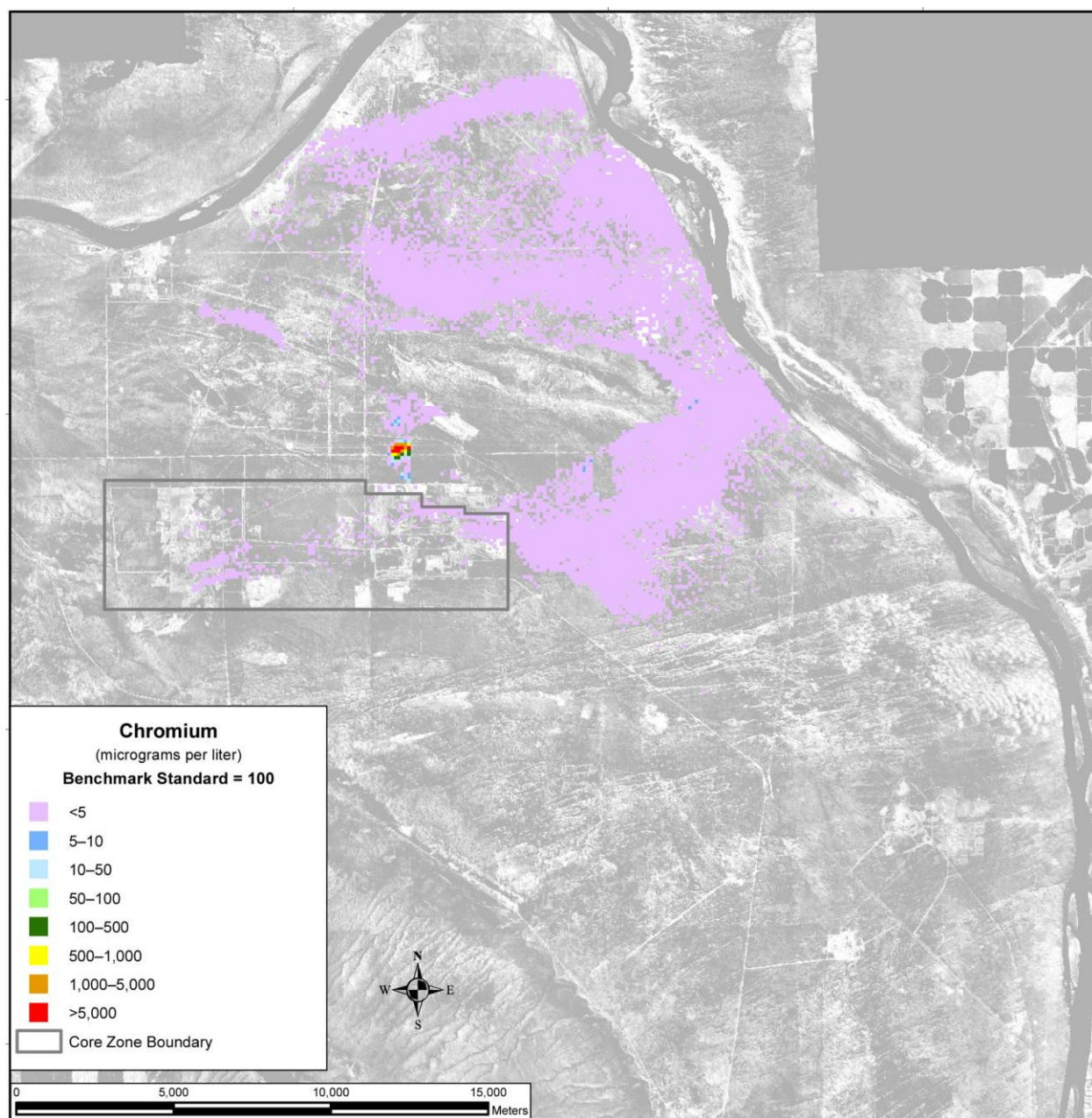
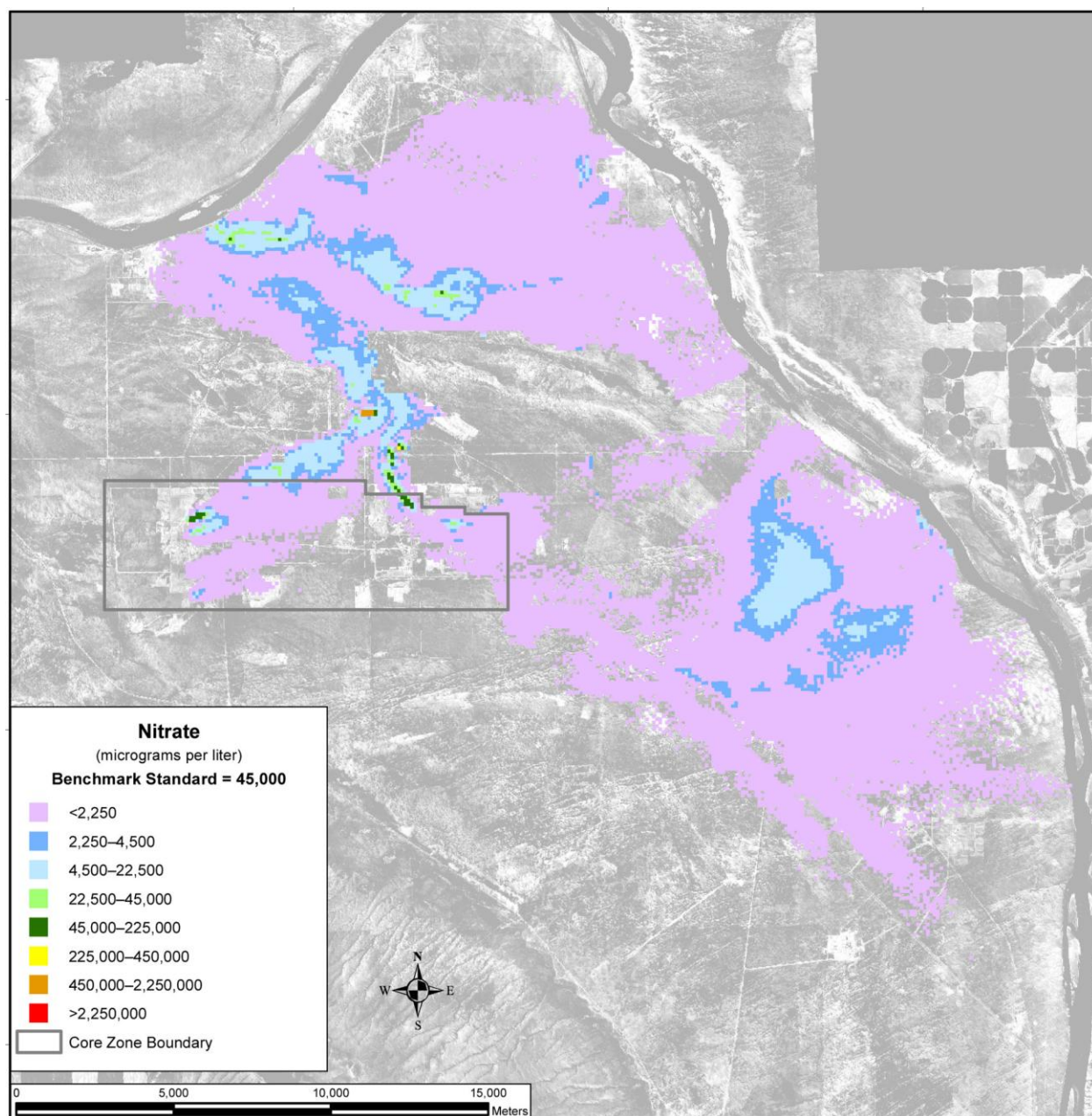
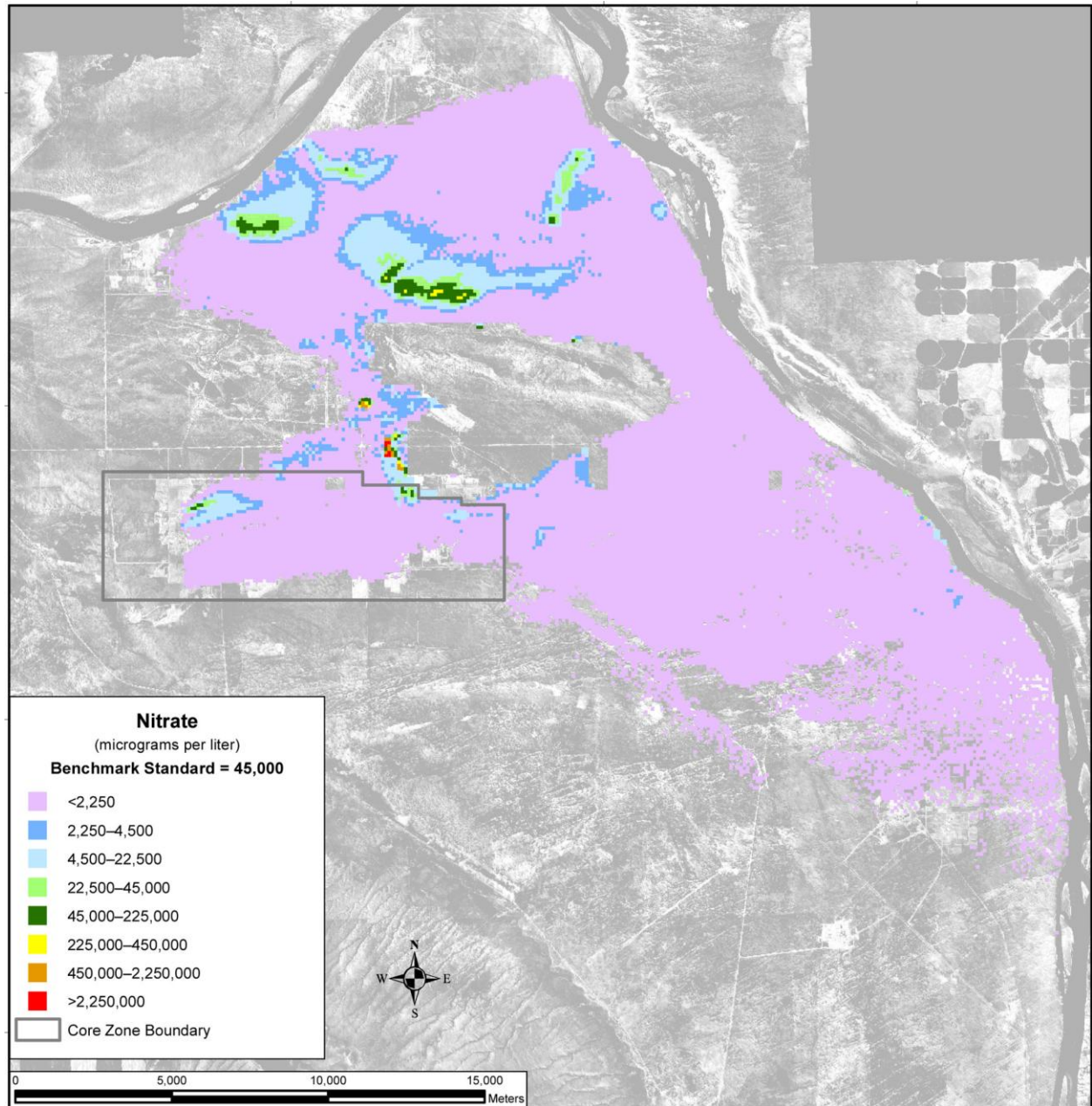


Figure 5–144. Tank Closure Alternative 4 Spatial Distribution of Groundwater Chromium Concentration, Calendar Year 7140

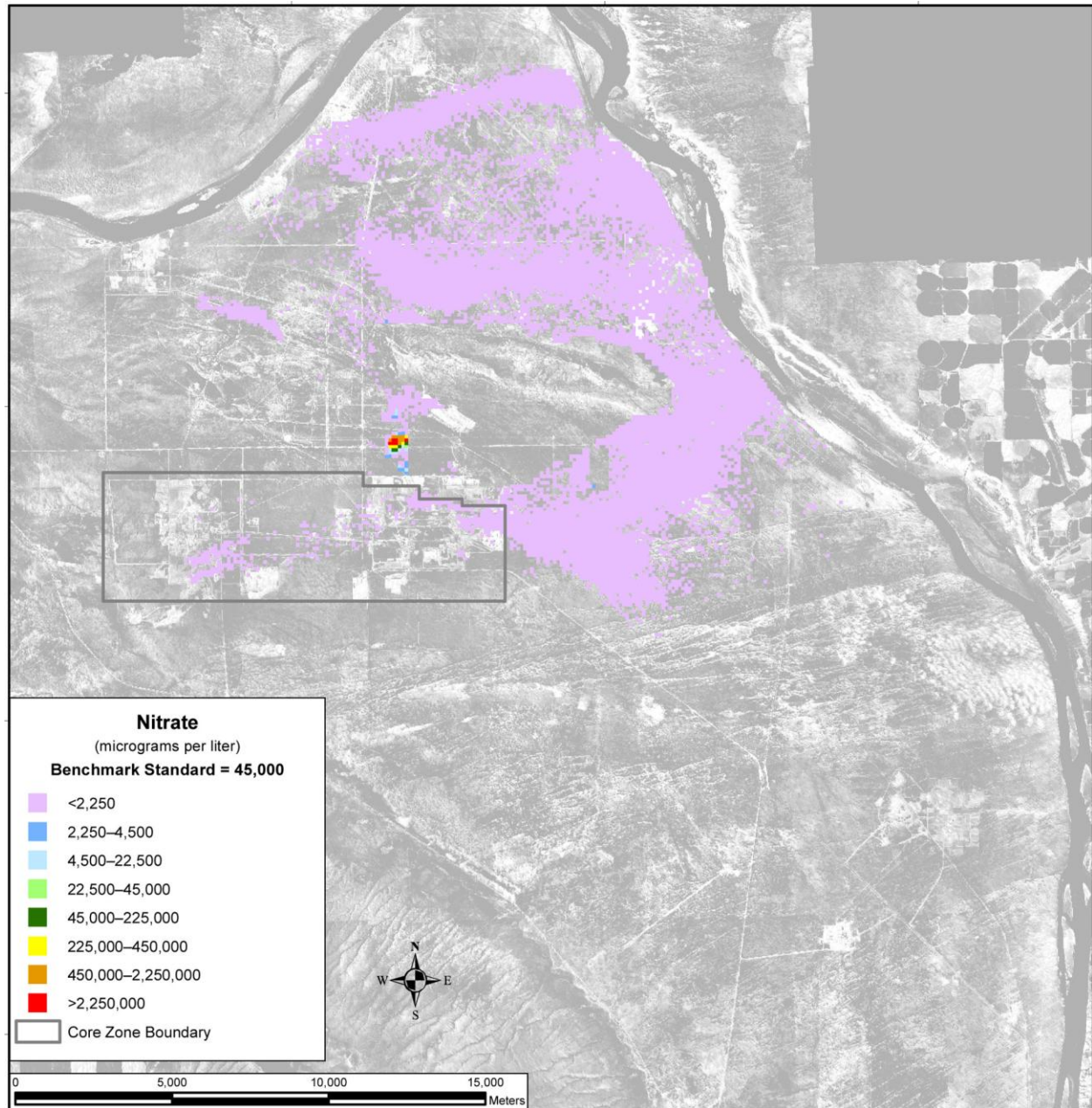


**Figure 5–145. Tank Closure Alternative 4 Spatial Distribution of Groundwater
Nitrate Concentration, Calendar Year 2010**



Note: To convert meters to feet, multiply by 3.281.

Figure 5–146. Tank Closure Alternative 4 Spatial Distribution of Groundwater Nitrate Concentration, Calendar Year 2135



**Figure 5–147. Tank Closure Alternative 4 Spatial Distribution of Groundwater
Nitrate Concentration, Calendar Year 7140**

Uranium-238 and total uranium show a different spatial distribution in the analysis over time. These COPCs are not as mobile as those discussed above, moving about seven times more slowly than the pore-water velocity. As a result, travel times through the vadose zone are longer, release to the aquifer is delayed, and travel times through the aquifer to the Columbia River are longer. The distribution of uranium-238 in CY 2010 is shown in Figure 5–148. There is a small plume associated with releases from cribs and trenches (ditches) and past leaks at the T Barrier that is less than one-twentieth of the benchmark concentration. This plume extends northeast through Gable Gap. By CY 2135 (see Figure 5–149), the area of the plume has grown, but there are no significant increases in peak concentration. By CY 7140 (see Figure 5–150), the size of the plume has increased and some areas of higher concentration begin to appear in the western part of the Core Zone Boundary and in the area north

of the Core Zone Boundary. In CY 11,940 (see Figure 5–151), the greatest development of the plume during the analysis period is seen, resulting primarily from releases during the past-practice period. Figures 5–152 through 5–155 show the corresponding results for total uranium, which has a similar distribution.

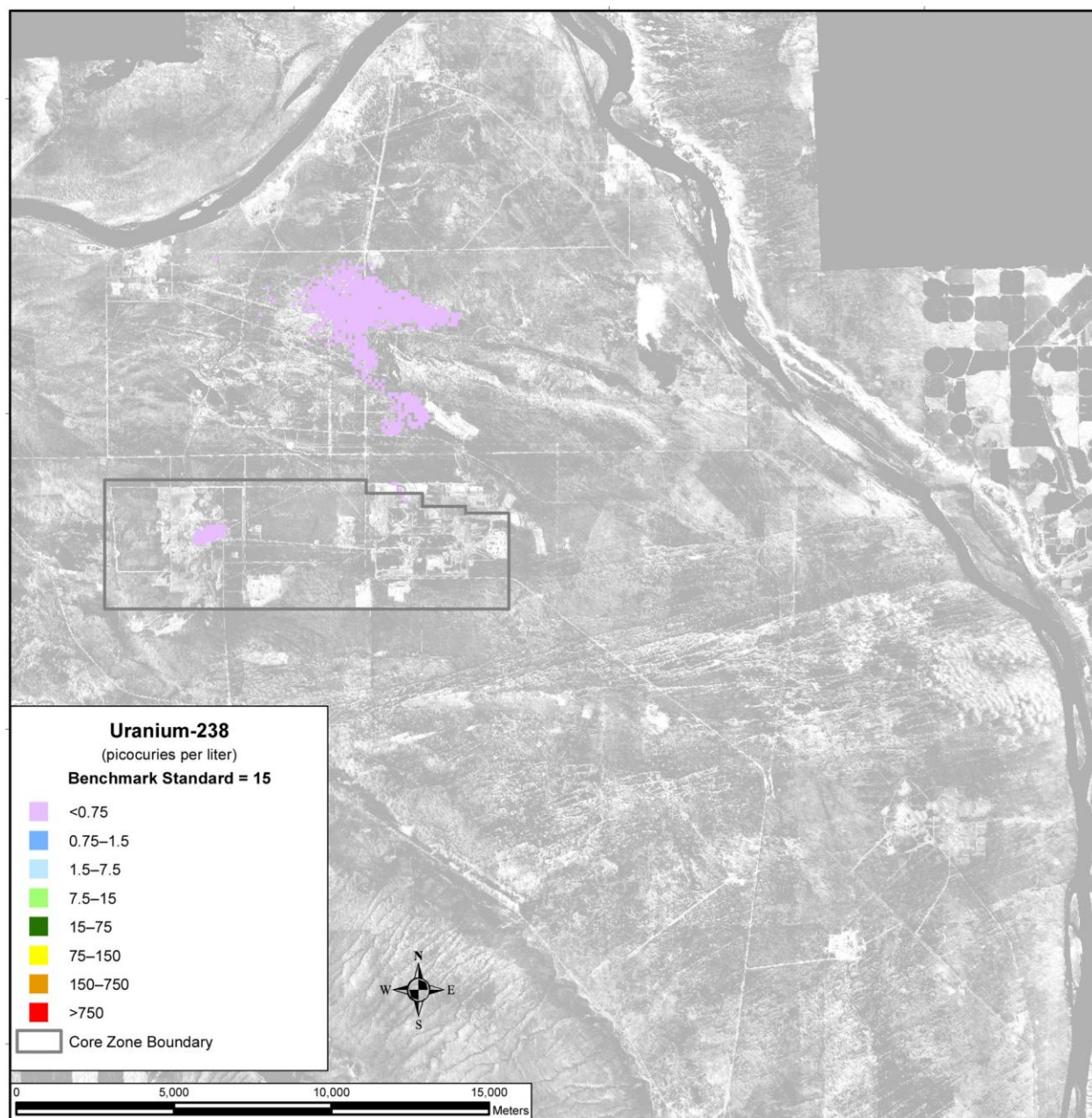
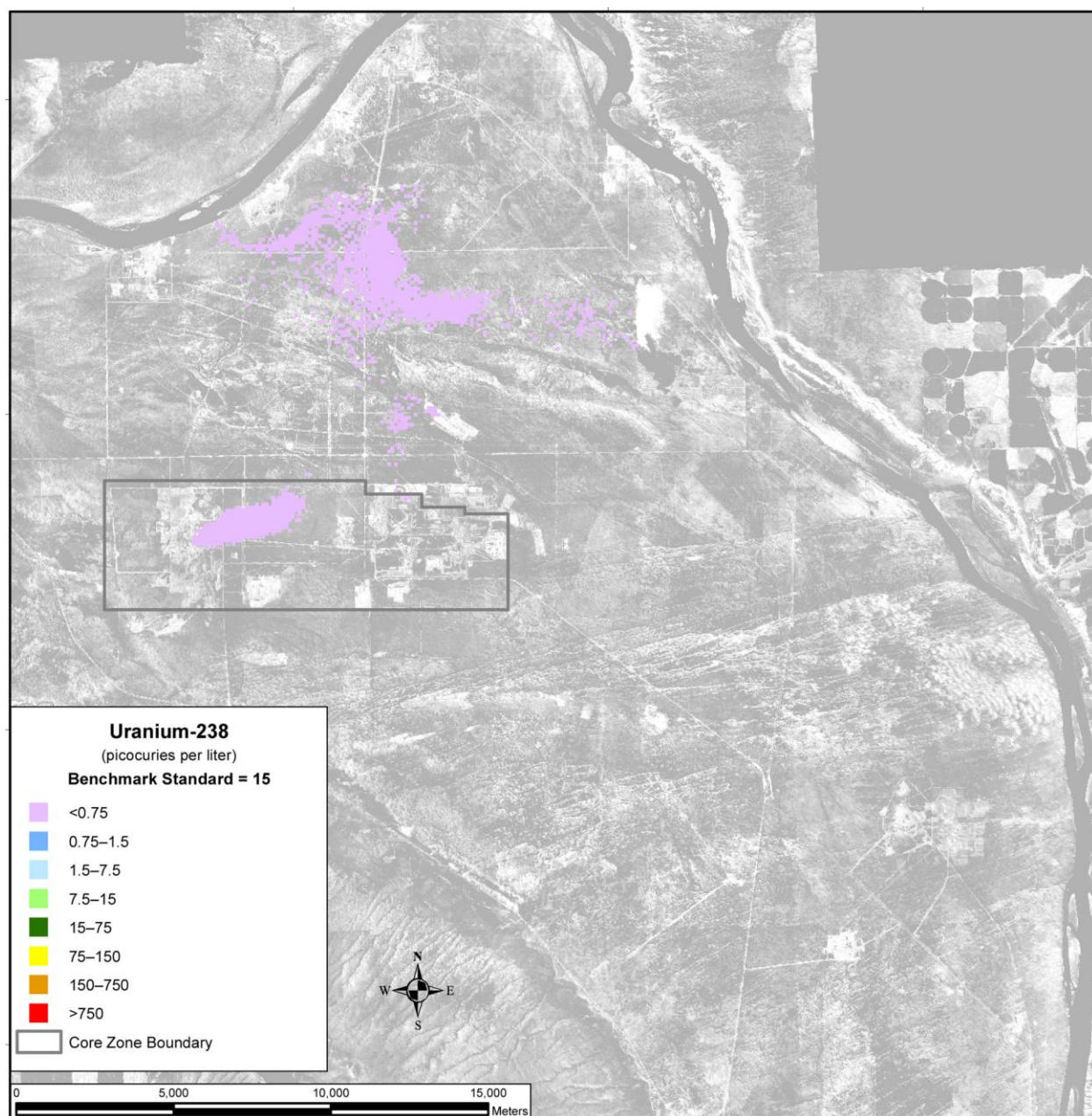


Figure 5–148. Tank Closure Alternative 4 Spatial Distribution of Groundwater Uranium-238 Concentration, Calendar Year 2010



**Figure 5–149. Tank Closure Alternative 4 Spatial Distribution of Groundwater
Uranium-238 Concentration, Calendar Year 2135**

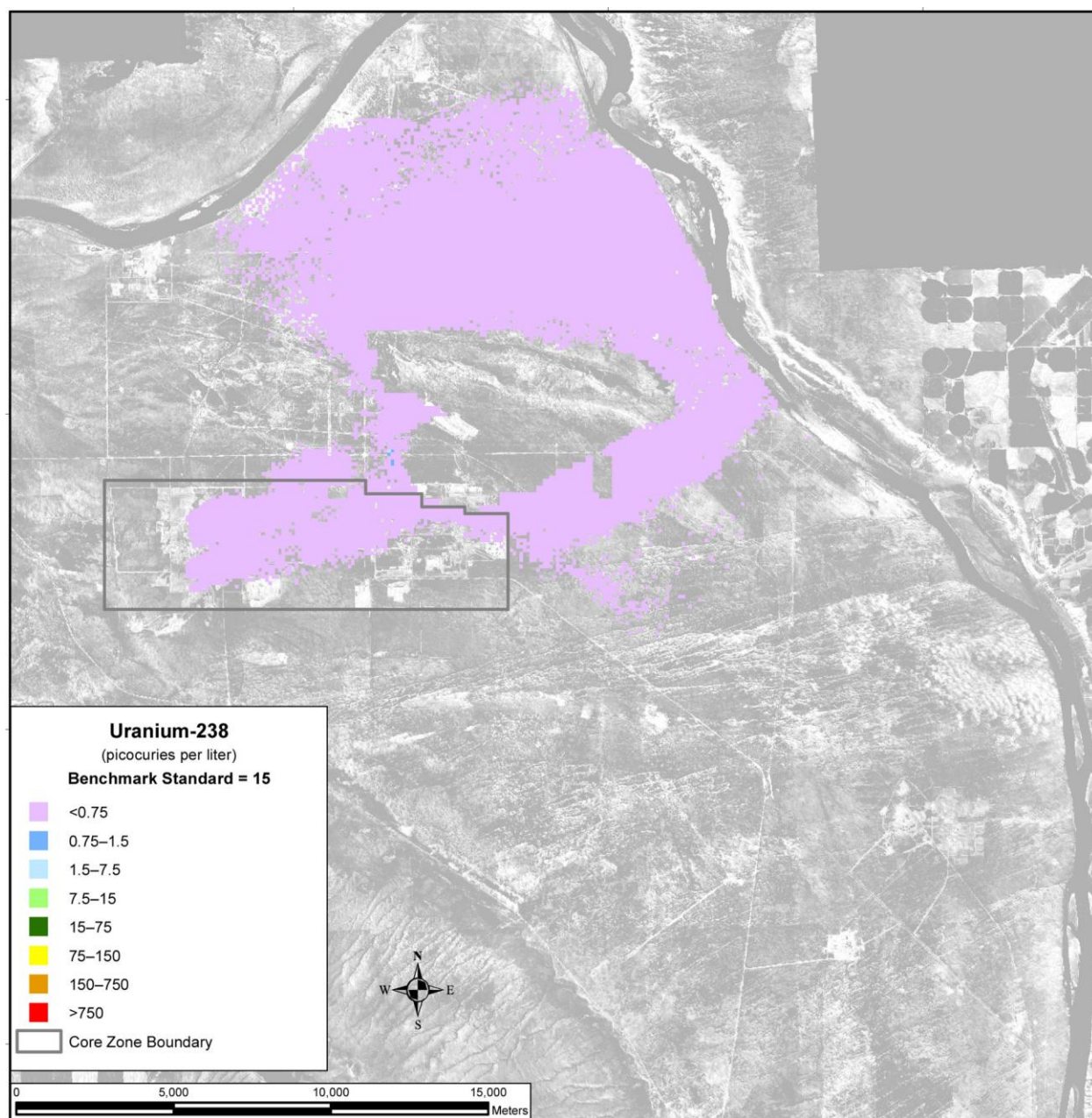
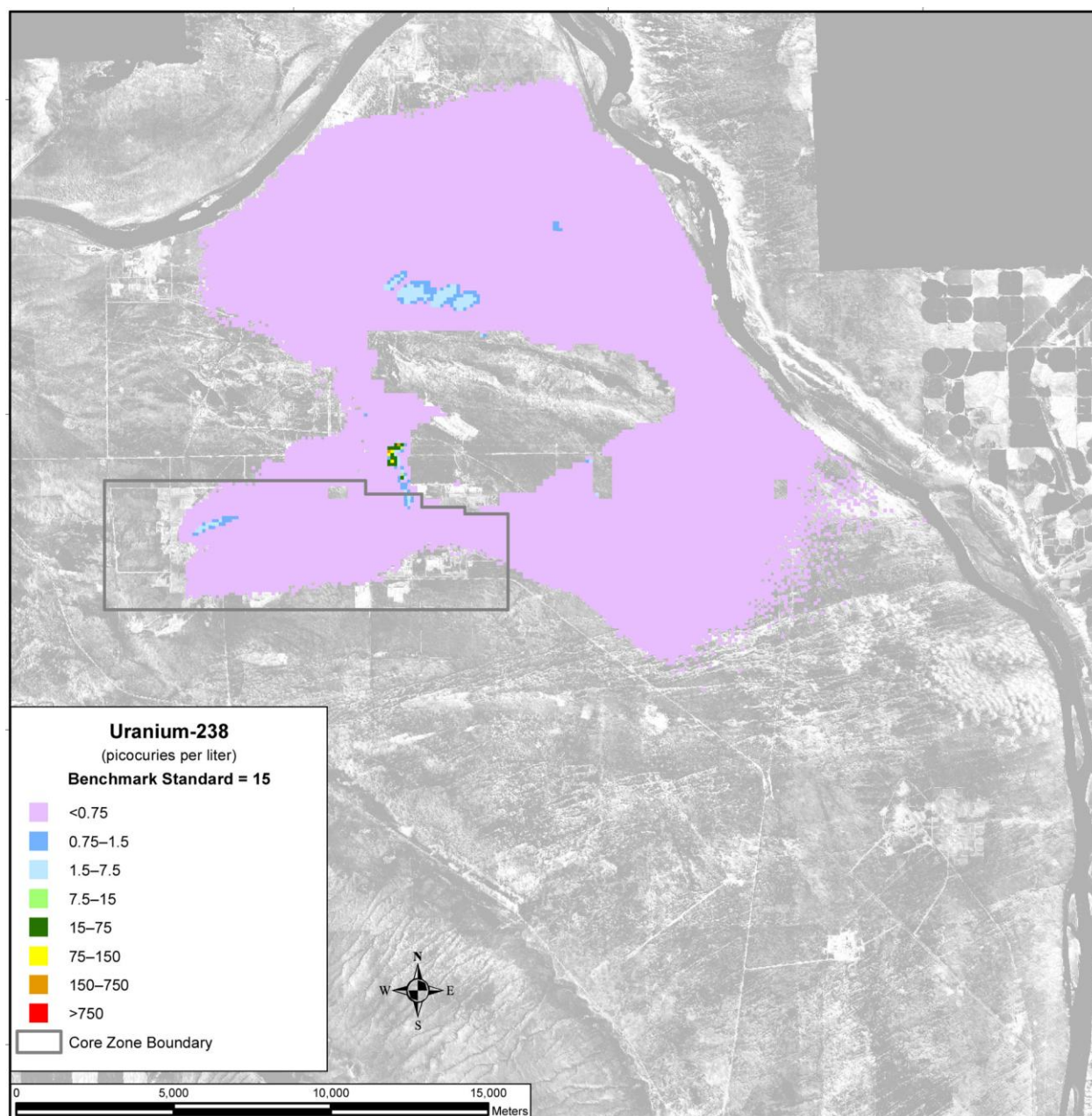


Figure 5–150. Tank Closure Alternative 4 Spatial Distribution of Groundwater Uranium-238 Concentration, Calendar Year 7140



**Figure 5–151. Tank Closure Alternative 4 Spatial Distribution of Groundwater
Uranium-238 Concentration, Calendar Year 11,940**

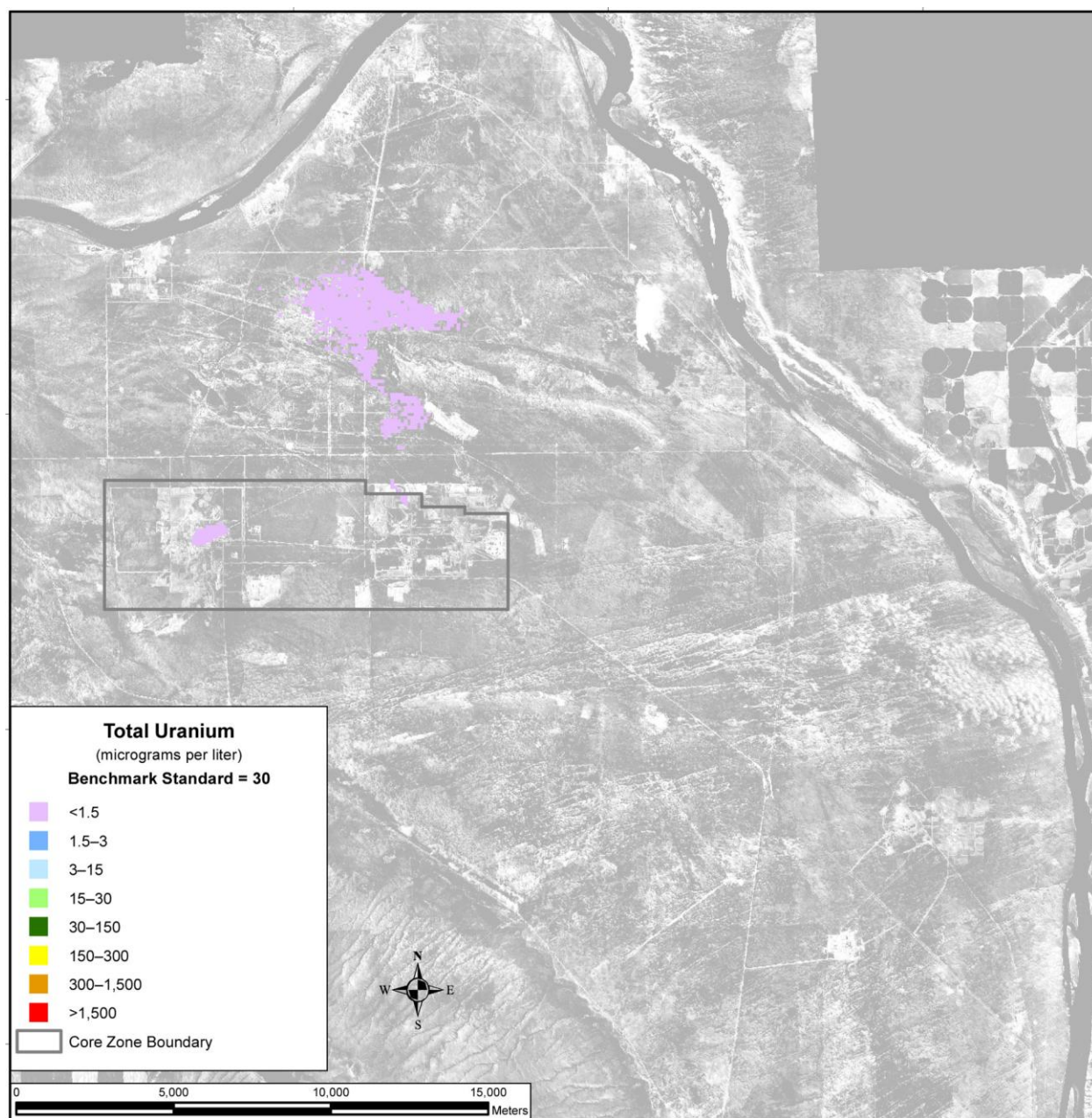
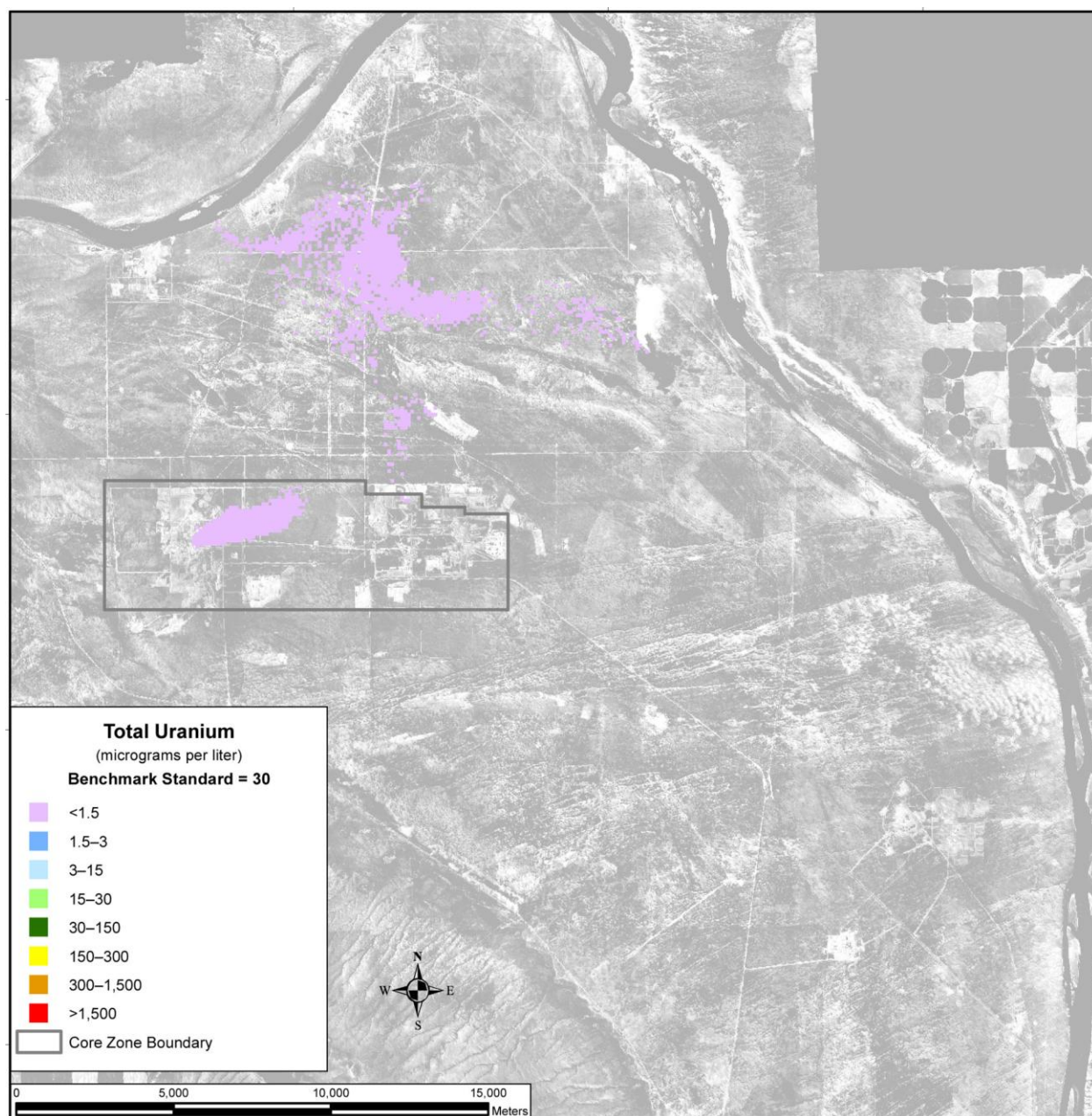
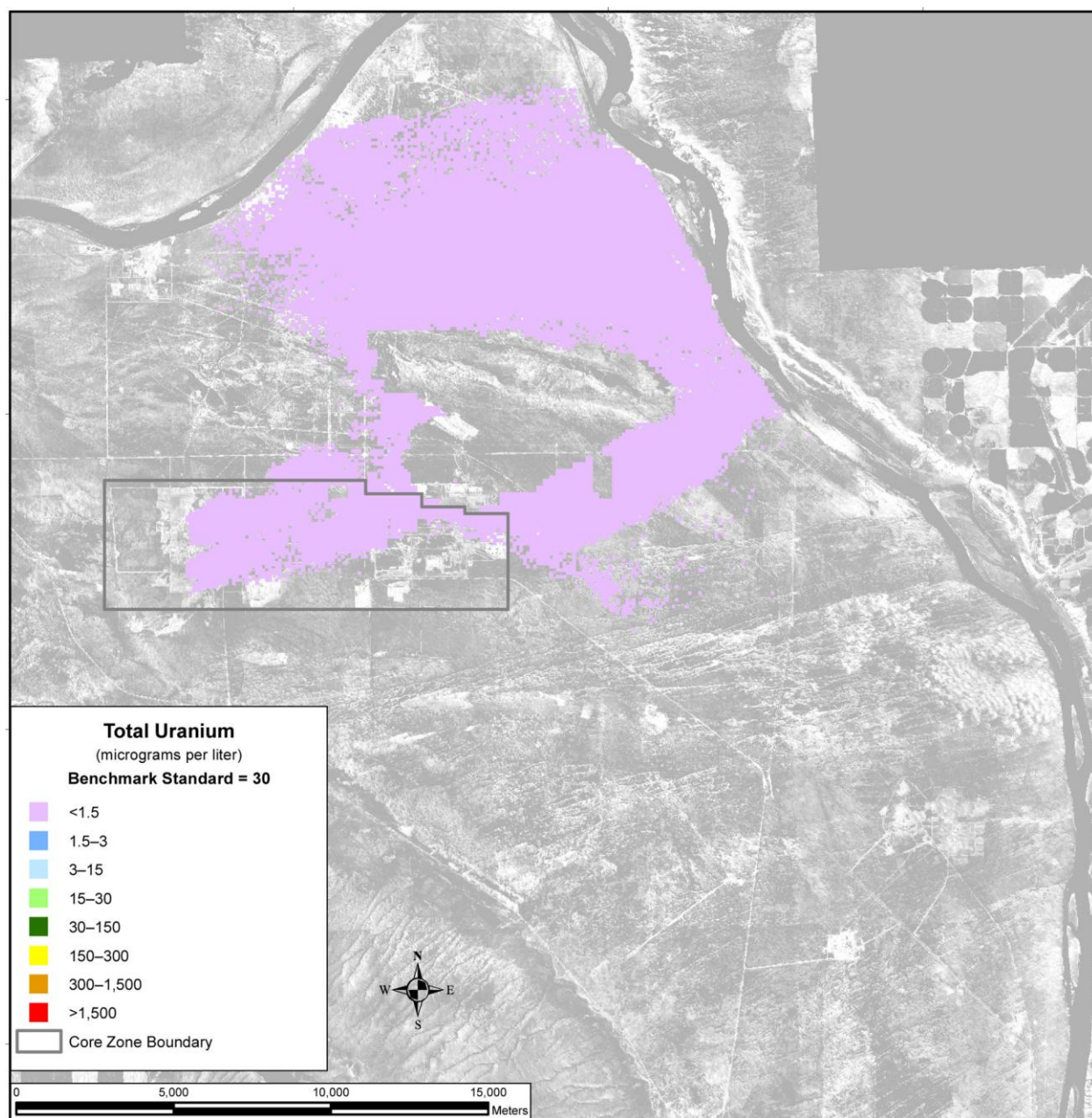


Figure 5–152. Tank Closure Alternative 4 Spatial Distribution of Groundwater Total Uranium Concentration, Calendar Year 2010

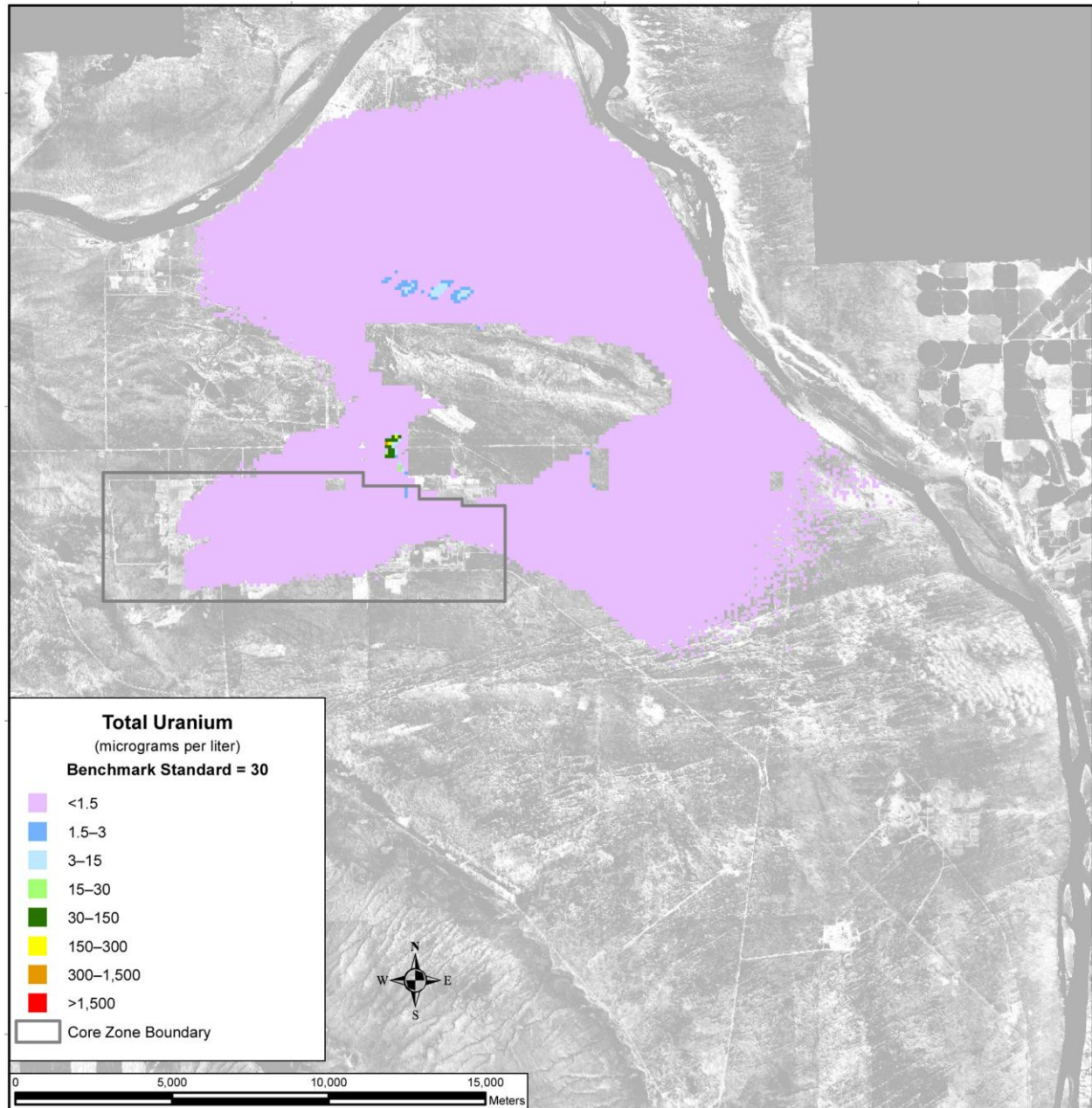


**Figure 5–153. Tank Closure Alternative 4 Spatial Distribution of Groundwater
Total Uranium Concentration, Calendar Year 2135**



Note: To convert meters to feet, multiply by 3.281.

Figure 5–154. Tank Closure Alternative 4 Spatial Distribution of Groundwater Total Uranium Concentration, Calendar Year 7140



**Figure 5–155. Tank Closure Alternative 4 Spatial Distribution of Groundwater
Total Uranium Concentration, Calendar Year 11,940**

Figures 5–156 through 5–158 show the area in which groundwater concentrations of iodine-129, technetium-99, and uranium-238 exceed their respective benchmark concentrations. Iodine-129 peaks early in the simulation, covering a peak area of 7 square kilometers (2.7 square miles) around CY 2100. This area drops below 0.76 square kilometers (0.3 square miles) around CY 3890, continuing its decline to 0.25 square kilometers (0.1 square miles) by CY 9740 and remaining near that level for the remainder of the simulation. Technetium-99 shows a similar trend, peaking at about 4.2 square kilometers (1.6 square miles) in CY 2070 and reaching 0.23 square kilometers (0.01 square miles) in CY 7790. Uranium-238 shows a distinctly different pattern, without any area above the benchmark concentration until CY 8340. From CY 8340 until the end of the simulation, areas in which uranium-238

concentrations exceed the benchmark concentration slowly increase, never surpassing 0.21 square kilometers (0.1 square miles).

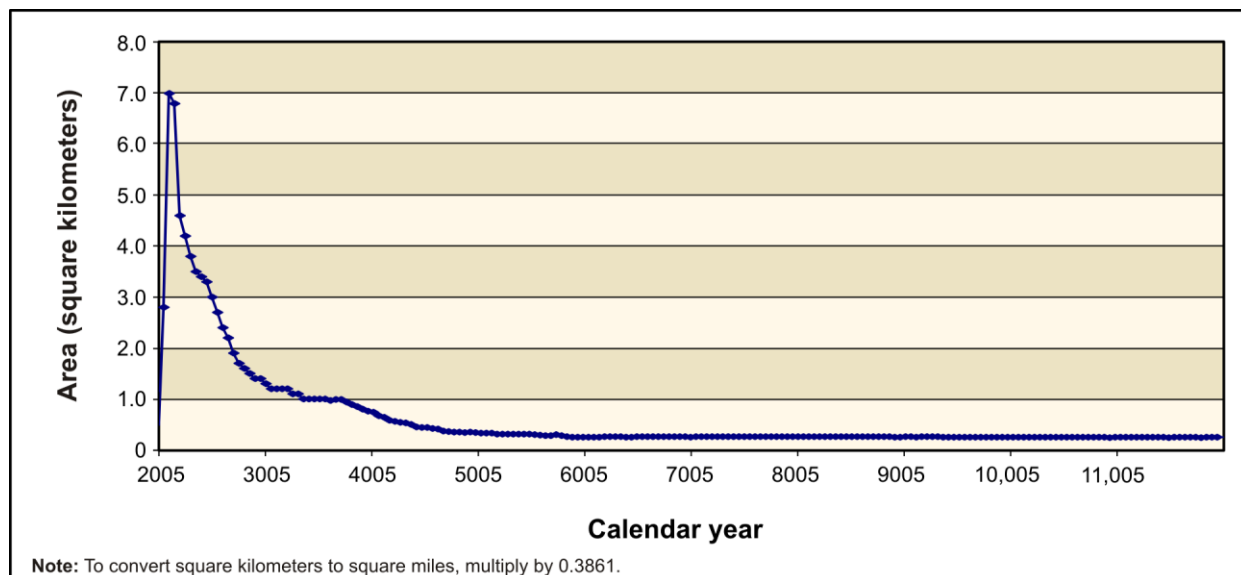


Figure 5–156. Tank Closure Alternative 4 Total Area of Groundwater Iodine-129 Concentration Exceeding the Benchmark Concentration as a Function of Time

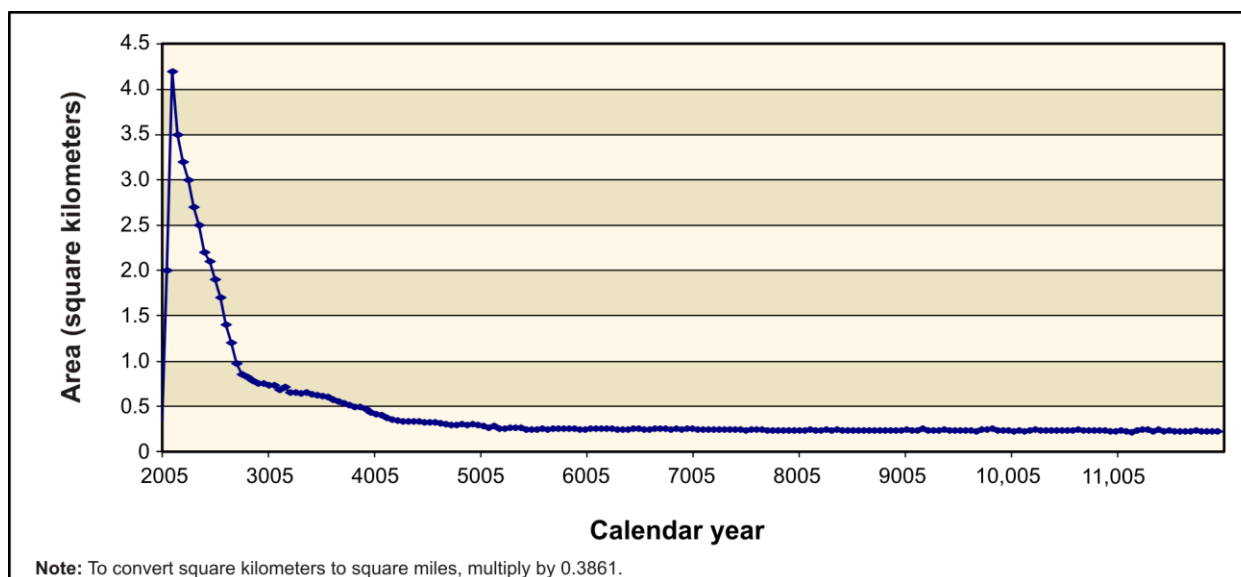


Figure 5–157. Tank Closure Alternative 4 Total Area of Groundwater Technetium-99 Concentration Exceeding the Benchmark Concentration as a Function of Time

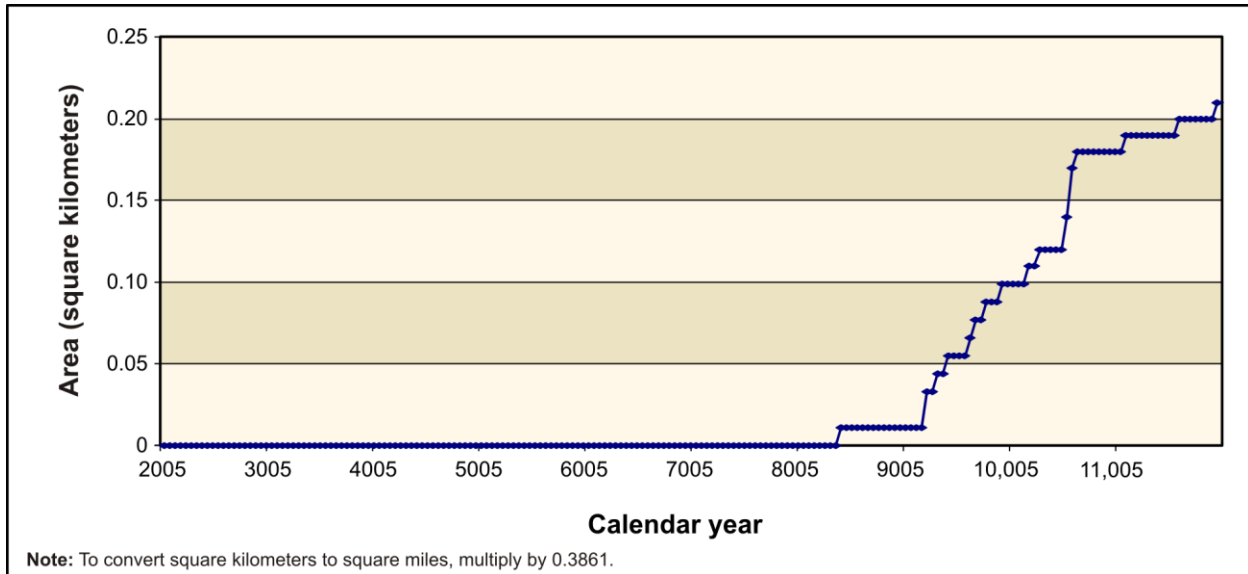


Figure 5-158. Tank Closure Alternative 4 Total Area of Groundwater Uranium-238 Concentration Exceeding the Benchmark Concentration as a Function of Time

5.1.1.7.6 Summary of Impacts

Under Tank Closure Alternative 4, discharges to cribs and trenches (ditches) and past leaks are the predominant contributors. Other tank farm sources, available during the post-administrative control period, are secondary contributors.

For the conservative tracers, concentrations at the Core Zone Boundary exceed benchmark standards by about one to two orders of magnitude during the early part of the period of analysis. Concentrations of conservative tracers at the Columbia River nearshore only exceed the benchmark for a short time during the past-practice period.

Concentrations of tritium at the Core Zone Boundary exceed the benchmark by about one to two orders of magnitude during the first 100 years of the period of analysis. Tritium concentrations at the Columbia River nearshore approach the benchmark during this time. Attenuation by radioactive decay is a predominant mechanism that limits the intensity and duration of groundwater impacts of tritium. After CY 2050, tritium impacts are essentially negligible.

For uranium-238 and total uranium, limited mobility is an important factor governing the timeframes and scale of groundwater impacts. Retention in the vadose zone during the operational period and subsequent removal of two tank farms (partial clean closure) reduce the impacts from past leaks and other tank farm sources. Concentrations of these retarded species never exceed the benchmark concentration at the Core Zone Boundary or at the Columbia River nearshore during the period of analysis. The intensity and area of the contamination plume continue to increase until the end of the analysis period.

5.1.1.8 Tank Closure Alternative 5: Expanded WTP Vitrification with Supplemental Treatment Technologies; Landfill Closure

This section describes the groundwater analysis results for Tank Closure Alternative 5, including long-term groundwater impacts of sources from within the tank farm barriers. Impacts of sources removed from within the tank farm barriers and disposed of in an IDF and the RPPDF are presented in Section 5.3, which discusses waste management impacts.

5.1.1.8.1 Actions and Timeframes Influencing Groundwater Impacts

Summaries of the proposed actions and timelines for Tank Closure Alternative 5 are provided in Chapter 2, Section 2.5. For the long-term groundwater impacts analysis, three major periods were identified for Tank Closure Alternative 5, as follows:

- The past-practice period was assumed to start with the onset of tank farm operations in 1944 and continue through 2007, when tank and infrastructure upgrades were complete. Releases to the vadose zone occurred during the past-practice period from past leaks at the SST farms and discharges to the cribs and trenches (ditches) associated with the B, BX, BY, T, TX, and TY tank farms. The groundwater impacts during the past-practice period under Tank Closure Alternative 5 presented in this section are common to all of the Tank Closure alternatives.
- The retrieval period was assumed to start in 2008 and end in CY 2139. This period includes waste retrieval, WTP pretreatment and treatment, landfill closure of the SST farm system, and 100 years of postclosure care. During this period, 90 percent of the waste would be retrieved from the tanks. A retrieval loss of 15,140 liters (4,000 gallons) per tank was assumed for all SSTs, with no leakage from DSTs or miscellaneous underground storage tanks. Retrieval leaks were assumed to occur over a period of 1 year (see Appendix M, Section M.5.1, for a discussion of the effect of variation of duration of leaks). The SST farm system would be landfill closed with the Hanford barrier. Releases that occurred during the past-practice period would continue to migrate through the vadose zone and groundwater system.
- The post-administrative control period was assumed to start in CY 2140 and continue through the 10,000-year period of analysis until CY 11,940. During this post-administrative control period, releases that occurred during the past-practice period would continue to migrate through the vadose zone and groundwater system. In addition, all remaining waste at the SST farms (other tank farm sources) would be released to the vadose zone at the start of the post-administrative control period.

5.1.1.8.2 COPC Drivers

A total of 19 COPCs were analyzed for Tank Closure Alternative 5. Complete results for all 19 COPCs are tabulated in Appendices M, N, and O, but this discussion of long-term impacts associated with Tank Closure Alternative 5 is focused on the following COPC drivers:

- Radiological risk drivers: tritium, iodine-129, technetium-99, and uranium-238
- Chemical risk drivers: none
- Chemical hazard drivers: chromium, nitrate, and total uranium

The COPC drivers for Tank Closure Alternative 5 were selected by evaluating the risk or hazard associated with all 19 COPCs during the year of peak risk or hazard at the Core Zone Boundary during the 10,000-year period of analysis and selecting the major contributors. This process is described in Appendix Q. Uranium-238 and total uranium were added to the COPC drivers; although their contributions to risk and hazard are not dominant during the year of peak risk or hazard, they become major contributors toward the end of the period of analysis. Tritium was added to the list of COPC drivers because of its contribution to risk during the early part of the period of analysis. The radiological risk drivers account for essentially 100 percent of the radiological risk. The only predicted chemical risk is from 2,4,6-trichlorophenol, calculated as 1×10^{-13} , which is negligible for purposes of this discussion. The chemical hazard drivers account for 100 percent of the chemical hazard associated with Tank Closure Alternative 5.

The COPC drivers that are discussed in detail in this section fall into three categories. Iodine-129, technetium-99, chromium, and nitrate are all mobile (i.e., move with groundwater) and long-lived (relative to the 10,000-year period of analysis), or stable. They are essentially conservative tracers. Tritium is also mobile, but short-lived. The half-life of tritium is about 13 years, and tritium concentrations are strongly attenuated by radioactive decay during travel through the vadose zone and groundwater systems. Finally, uranium-238 and total uranium are long-lived, or stable, but are not as mobile as the other COPC drivers. These constituents move about seven times more slowly than groundwater. As the analyses of release, concentration versus time, and spatial distribution of the COPC drivers are presented, the distinct behavior of these three groups will become apparent.

The other COPCs that were analyzed do not significantly contribute to drinking water risk at the Core Zone Boundary during the period of analysis because of limited inventories, high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of these factors.

5.1.1.8.3 Analysis of Release and Mass Balance

This section presents the impacts of Tank Closure Alternative 5 in terms of the total amount of COPCs released to the vadose zone, groundwater, and the Columbia River during the 10,000-year period of analysis. Releases of radionuclides are totaled in curies; chemicals, in kilograms (see Figures 5–159 through 5–164). Three subtotals are plotted, representing releases from cribs and trenches (ditches), past leaks, and other tank farm sources (e.g., tank residuals, ancillary equipment). Note that the release amounts are plotted on a logarithmic scale to facilitate visual comparison of releases that vary over four orders of magnitude within the same series of figures.

Figure 5–159 shows the estimated release to the vadose zone of the radiological risk drivers and Figure 5–160, the chemical hazard drivers. For all three types of sources, the release to the vadose zone is controlled by the inventory (i.e., 90 percent of the inventory is removed during the period of analysis by supplemental treatment technologies). The predominant sources of tritium, chromium, and nitrate are the cribs and trenches (ditches) associated with the B, BX, BY, T, TX, and TY tank farms. For all other COPC drivers, the predominant sources are other tank farm sources. This suggests that other tank farm sources, which are released in the analysis during the post-administrative control period, are an important impact driver under Tank Closure Alternative 5.

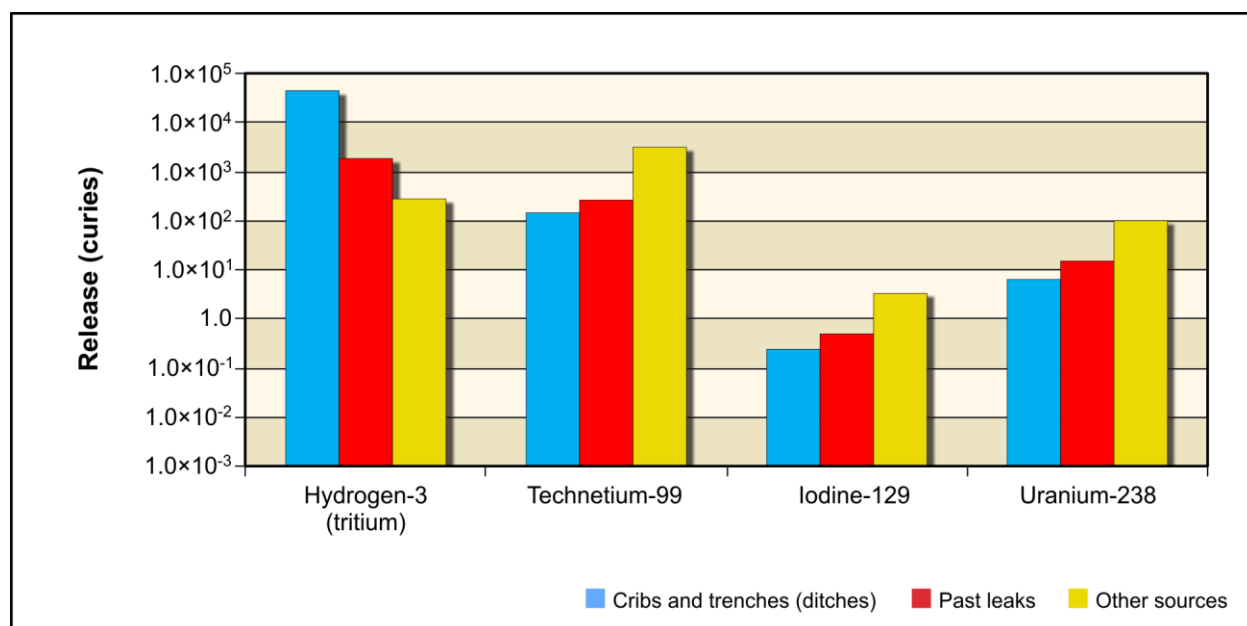


Figure 5–159. Tank Closure Alternative 5 Releases of Radioactive Constituent of Potential Concern Drivers to Vadose Zone for Entire 10,000-Year Analysis Period

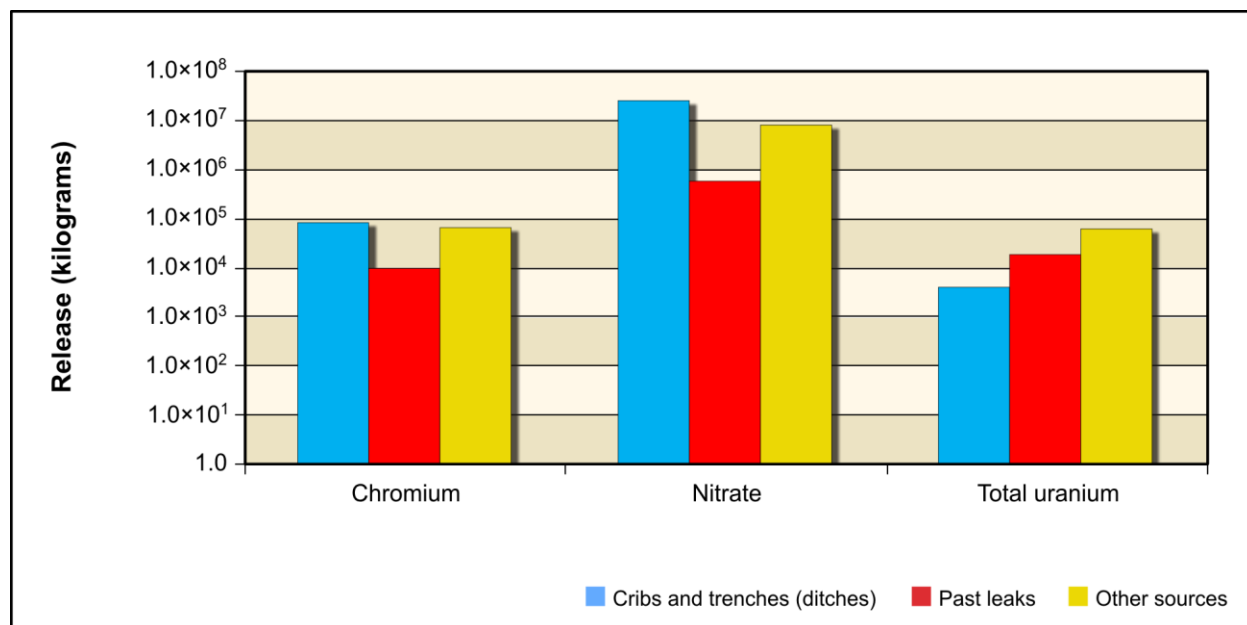


Figure 5–160. Tank Closure Alternative 5 Releases of Chemical Constituent of Potential Concern Drivers to Vadose Zone for Entire 10,000-Year Analysis Period

Figure 5–161 shows the estimated release to groundwater of the radiological risk drivers and Figure 5–162, the chemical hazard drivers. In addition to the inventory considerations discussed in the previous paragraph, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. For the conservative tracers (iodine-129, technetium-99, chromium, and nitrate), the amount released to groundwater is essentially equal to the amount released to the vadose zone.

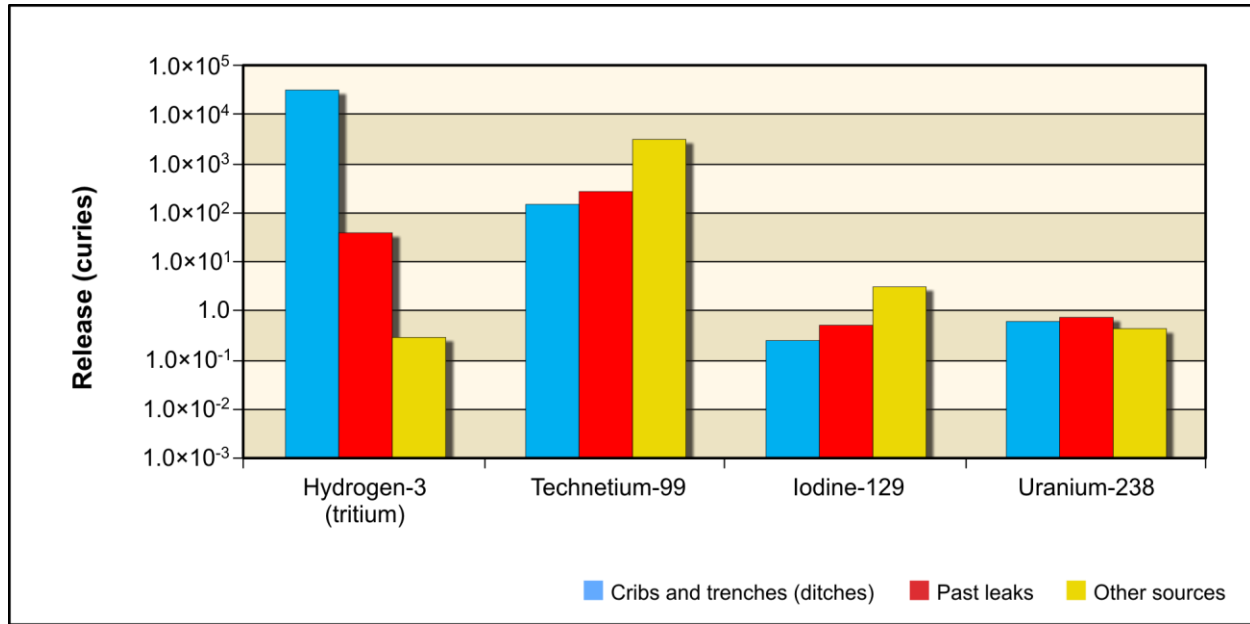


Figure 5–161. Tank Closure Alternative 5 Releases of Radioactive Constituent of Potential Concern Drivers to Groundwater for Entire 10,000-Year Analysis Period

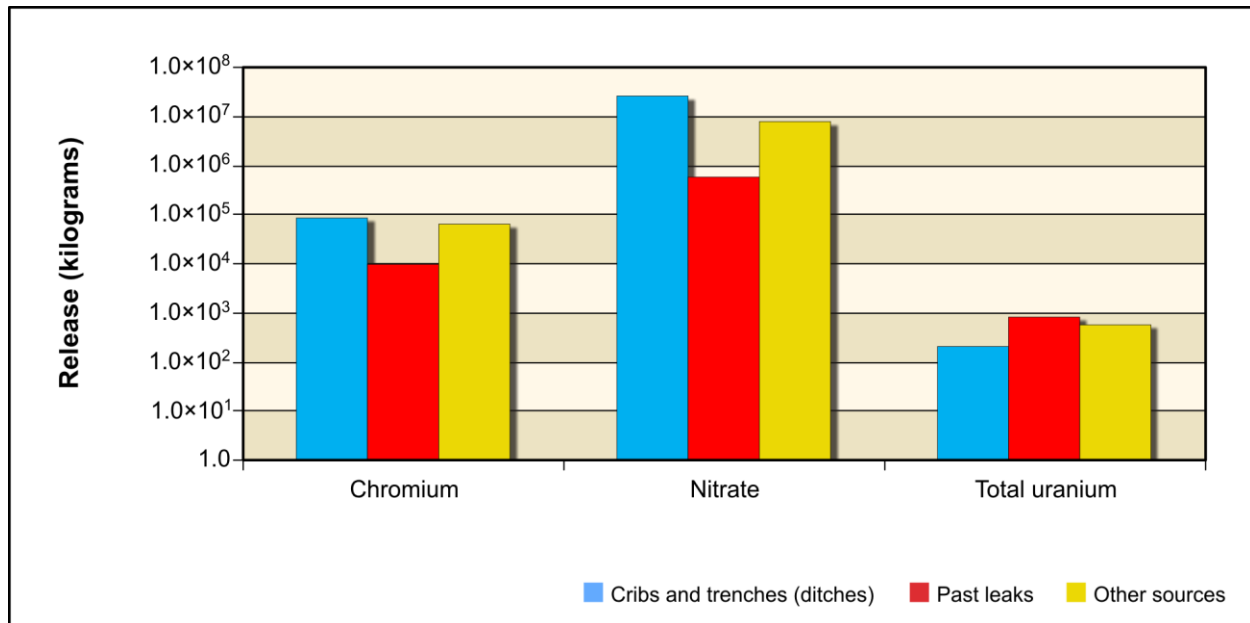


Figure 5–162. Tank Closure Alternative 5 Releases of Chemical Constituent of Potential Concern Drivers to Groundwater for Entire 10,000-Year Analysis Period

For uranium-238 and total uranium, the amount released to groundwater is less than that released to the vadose zone because of vadose zone retention. The amount of this retention depends on the type of contaminant source, specifically volume and timing of moisture movement through the vadose zone. For releases from cribs and trenches (ditches) and past leaks, where moisture movement through the vadose zone is relatively rapid (because of the volume of water associated with the source), about 15 percent of the inventory of uranium-238 and 9 percent of the inventory of total uranium reach groundwater during the period of analysis; for other tank farm sources, less than 1 percent reaches groundwater.

For tritium, the amount released to groundwater is attenuated by radioactive decay. For releases from cribs and trenches (ditches), about 70 percent of the total inventory reaches groundwater in the analysis; for past leaks, only 2 percent; and for other tank farm sources, only one-tenth of 1 percent reaches the water table. These results suggest that tritium impacts on groundwater are dominated by releases from cribs and trenches (ditches) and that radioactive decay of tritium is an important attenuation process. They also suggest that uranium-238 and total uranium impacts on groundwater would occur later in the post-administrative control period because of the long travel times in the vadose zone for these COPCs.

Figure 5–163 shows the estimated release to the Columbia River of the radiological risk drivers and Figure 5–164, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. For the conservative tracers (iodine-129, technetium-99, chromium, and nitrate), the amount released to the Columbia River is essentially equal to the amount released to groundwater. For uranium-238 and total uranium, the amount released to the Columbia River is less than that released to groundwater because of retardation. Overall, about 28 percent of the uranium-238 and 24 percent of the total uranium released to groundwater during the period of analysis reach the Columbia River. For tritium, the amount released to the Columbia River is attenuated by radioactive decay. Overall, only about 1 percent of the tritium released to groundwater reaches the Columbia River during the period of analysis. These results suggest that tritium impacts on the Columbia River are strongly attenuated by radioactive decay.

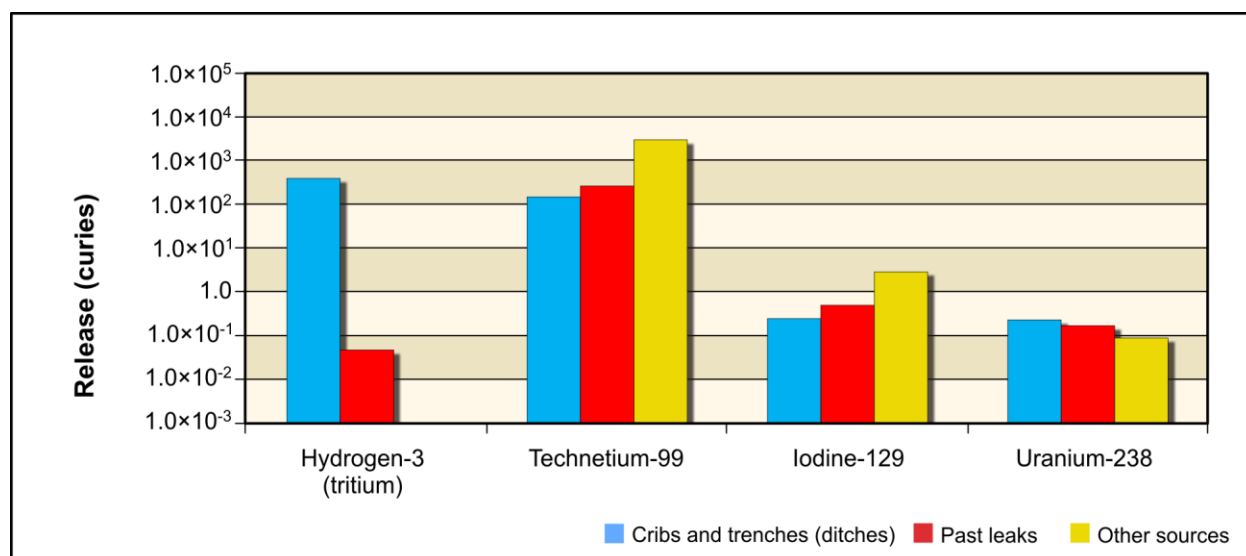


Figure 5–163. Tank Closure Alternative 5 Releases of Radioactive Constituent of Potential Concern Drivers to Columbia River for Entire 10,000-Year Analysis Period

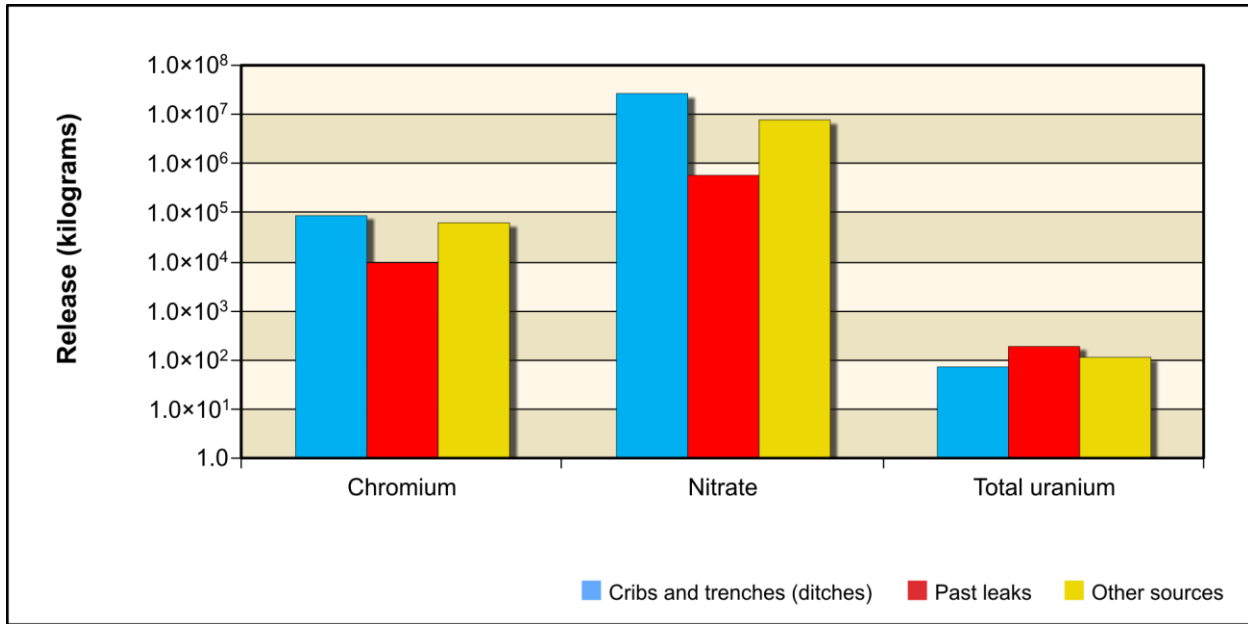


Figure 5–164. Tank Closure Alternative 5 Releases of Chemical Constituent of Potential Concern Drivers to Columbia River for Entire 10,000-Year Analysis Period

5.1.1.8.4 Analysis of Concentration Versus Time

This section presents the analysis of Tank Closure Alternative 5 impacts in terms of groundwater concentration versus time at the Core Zone Boundary and the Columbia River nearshore. Concentrations of radionuclides are in picocuries per liter; chemicals, in micrograms per liter (see Table 5–11 and Figures 5–165 through 5–171). The benchmark concentration of each radionuclide and chemical is also shown. Note that the concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations that vary over five orders of magnitude. Table 5–11 lists the maximum concentrations of the COPCs in the peak year after CY 2050 at the tank farm barriers, Core Zone Boundary, and Columbia River nearshore. Under Tank Closure Alternative 5, tritium, uranium-238, and total uranium never exceed their benchmark concentrations at any location beyond CY 2050. The highest impacts occur at the B and T Barriers and the Core Zone Boundary, where concentrations of iodine-129, technetium-99, chromium, and nitrate exceed their respective benchmark concentrations. None of the COPC drivers exceed the benchmark concentration at the Columbia River nearshore.

Figure 5–165 shows concentration versus time for tritium. Releases from cribs and trenches (ditches) cause Core Zone Boundary groundwater concentrations to exceed benchmark concentrations by one to two orders of magnitude for a short period of time during the early part of the period of analysis. This time period is represented by the first series of sharp inflections in the curve for the Core Zone Boundary from approximately CY 1955 until CY 1980. During this time, groundwater concentrations at the Columbia River nearshore approach but never exceed the benchmark concentration. Because the half-life of tritium is less than 13 years, radioactive decay rapidly attenuates groundwater concentration, and tritium is essentially not a factor at times later than CY 2050.

Figures 5–166 through 5–169 show concentration versus time for iodine-129, technetium-99, chromium, and nitrate (the conservative tracers). Releases from cribs and trenches (ditches) cause groundwater concentrations of iodine-129 to exceed benchmark concentrations by about two to three orders of magnitude at the Core Zone Boundary during the early part of the period of analysis. This early time period is represented by the multiple sharp inflections in the Core Zone Boundary curve that occur between approximately CY 1955 and CY 1980. The iodine-129 signature also occurs at the Columbia

River nearshore at a later time. Tank farm residuals result in a broad concentration peak that hovers at or just below the benchmark concentration from about CY 3500 to the end of the period of analysis; this result indicates that the less effective (i.e., 90 percent) retrieval of the tank waste residuals under this alternative is not offset by the limitation of infiltration from the Hanford barriers over the tank farms. Under Tank Closure Alternative 4, in which 99.9 percent of the tank waste residuals would be retrieved, the iodine-129 concentrations resulting from releases from tank farm residuals drop below the benchmark after CY 2500. Under Tank Closure Alternative 5, groundwater iodine-129 concentrations at the Columbia River nearshore approach the benchmark concentration for a short time during the early period of analysis; thereafter, concentrations stay below the benchmark. Technetium-99, chromium, and nitrate concentrations show similar concentration-versus-time behavior.

Table 5–11. Tank Closure Alternative 5 Maximum COPC Concentrations in the Peak Year at the Tank Farm Barriers, Core Zone Boundary, and Columbia River Nearshore

Contaminant	A Barrier	B Barrier	S Barrier	T Barrier	U Barrier	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide (picocuries per liter)								
Hydrogen-3 (tritium)	7 (2051)	579 (2052)	32 (2050)	2,870 (2050)	15 (2050)	628 (2051)	477 (2051)	20,000
Technetium-99	1,110 (4155)	3,880 (3616)	3,440 (4314)	6,630 (2050)	1,420 (3949)	3,880 (3616)	479 (4918)	900
Iodine-129	1.4 (2107)	4.4 (2056)	2.8 (2050)	12.8 (2050)	0.5 (4371)	4.4 (2056)	0.8 (2334)	1
Uranium isotopes (includes U-233, -234, -235, -238)	0 (11,832)	3 (11,938)	0 (11,918)	2 (11,895)	0 (11,904)	3 (11,938)	0 (11,935)	15
Chemical (micrograms per liter)								
Chromium	79 (2168)	215 (2050)	158 (2050)	354 (2051)	30 (3565)	215 (2050)	71 (2076)	100
Nitrate	17,800 (2172)	171,000 (2055)	10,100 (4088)	62,000 (2053)	3,440 (3568)	171,000 (2055)	17,200 (2122)	45,000
Total uranium	0 (11,854)	5 (11,793)	0 (11,829)	1 (11,810)	0 (11,828)	5 (11,793)	0 (11,938)	30

Note: Corresponding calendar years shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.

Key: COPC=constituent of potential concern.

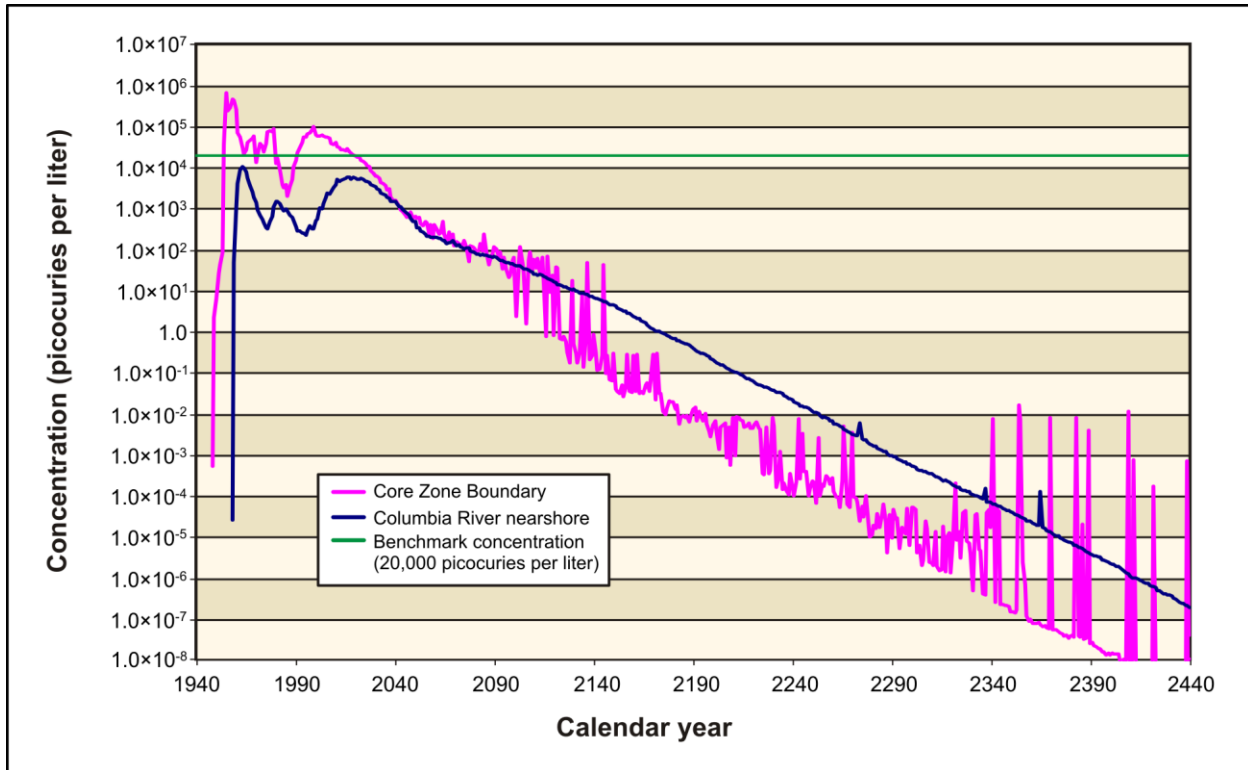


Figure 5-165. Tank Closure Alternative 5 Hydrogen-3 (Tritium) Concentration Versus Time

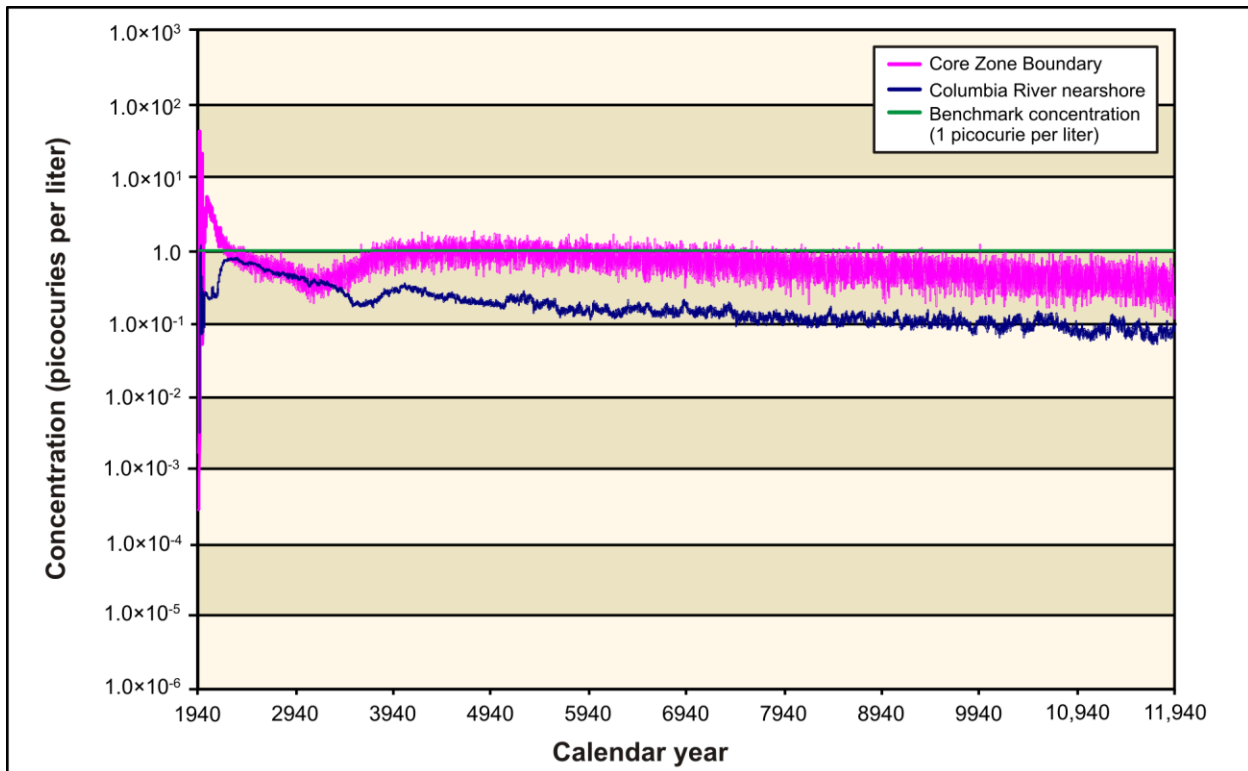


Figure 5-166. Tank Closure Alternative 5 Iodine-129 Concentration Versus Time

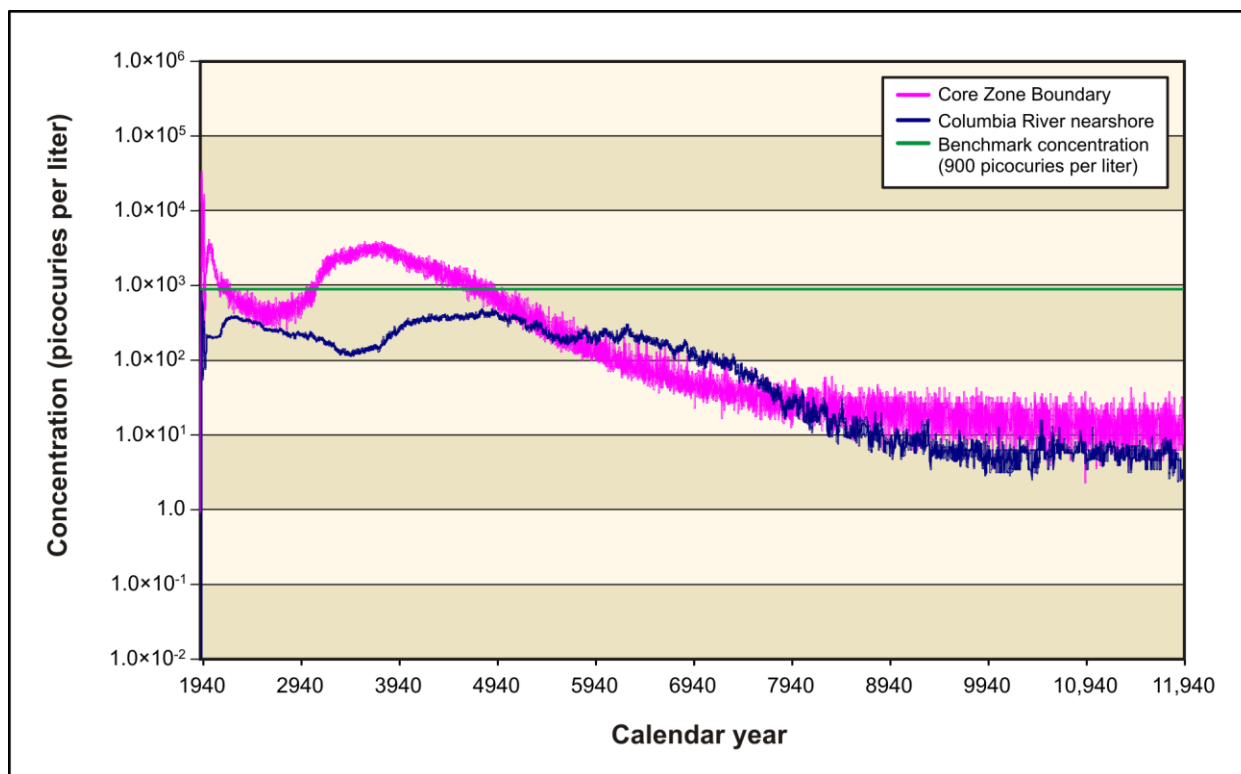


Figure 5-167. Tank Closure Alternative 5 Technetium-99 Concentration Versus Time

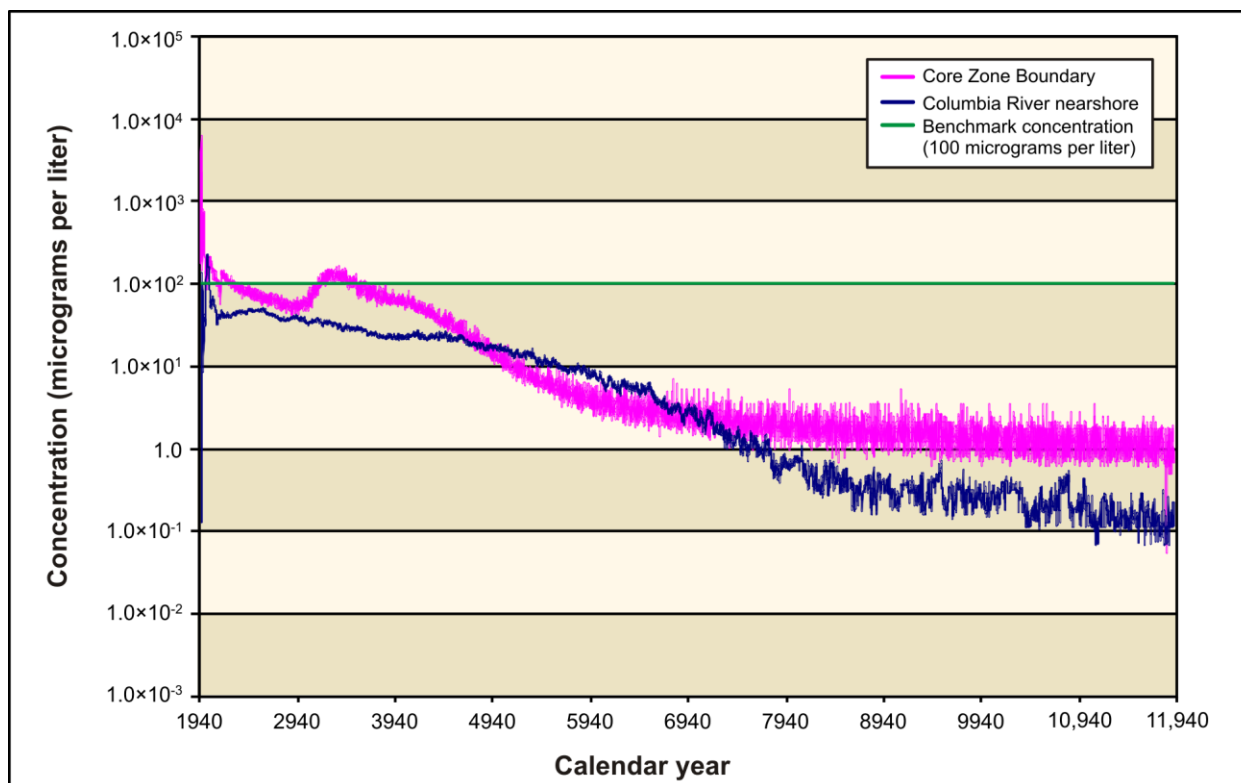


Figure 5-168. Tank Closure Alternative 5 Chromium Concentration Versus Time

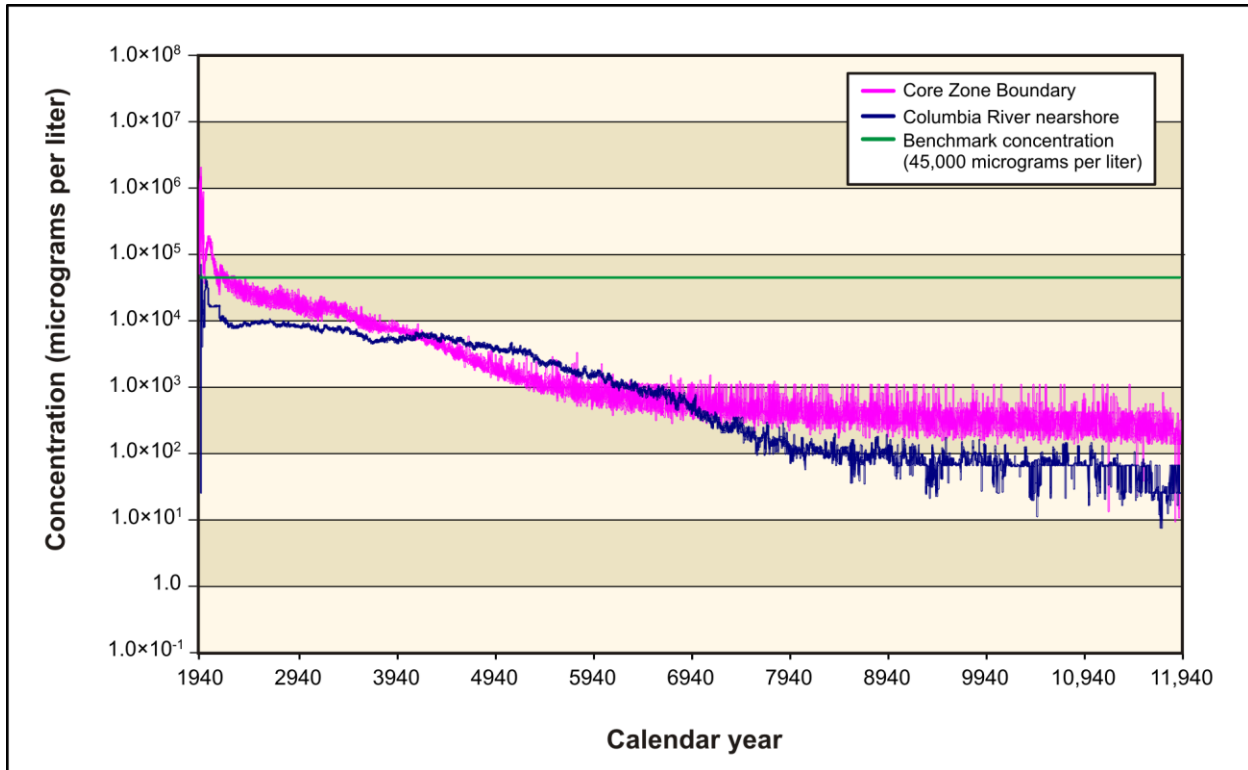


Figure 5-169. Tank Closure Alternative 5 Nitrate Concentration Versus Time

Figures 5-170 and 5-171 show concentration versus time for uranium-238 and total uranium. Early releases from cribs and trenches (ditches) result in groundwater concentrations that are about two orders of magnitude lower than benchmark concentrations. Releases from other tank farm sources cause groundwater concentrations to rise throughout the period of analysis. Groundwater concentrations at the Core Zone Boundary and Columbia River nearshore never exceed the benchmark concentration during the period of analysis.

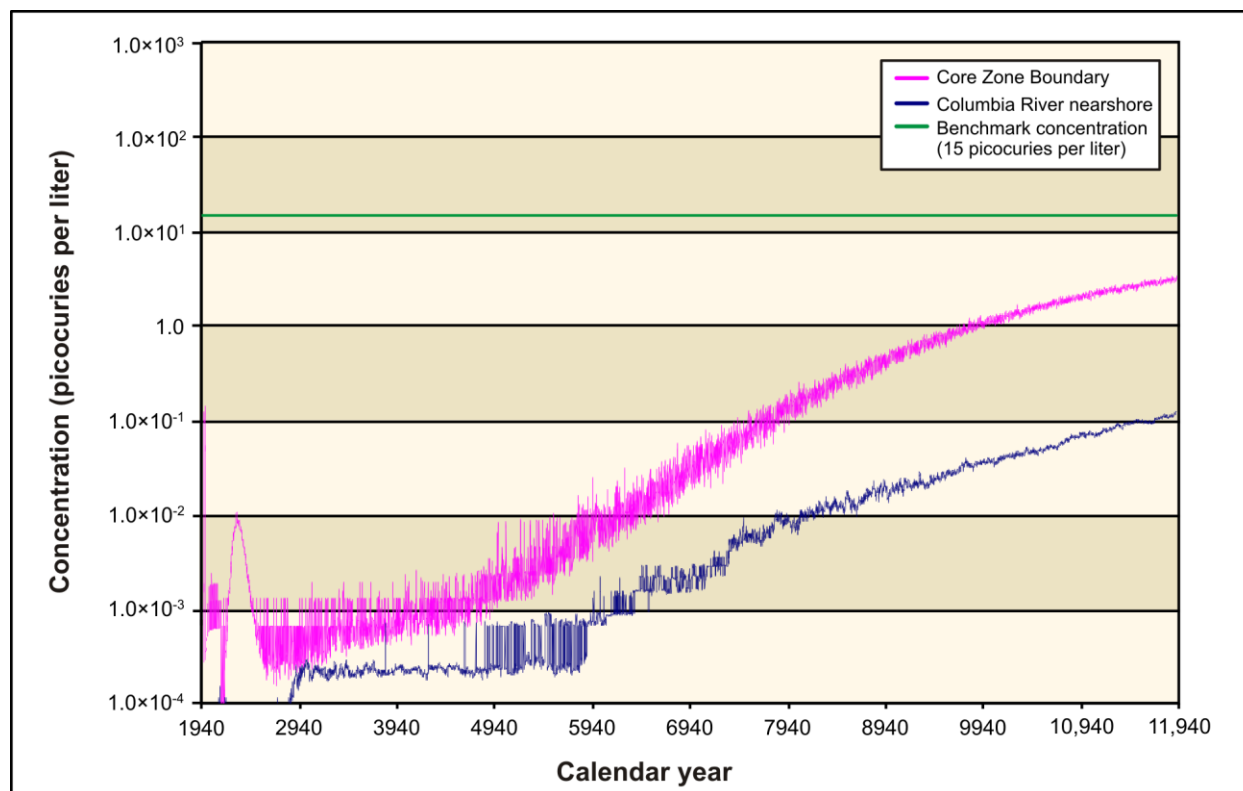


Figure 5-170. Tank Closure Alternative 5 Uranium-238 Concentration Versus Time

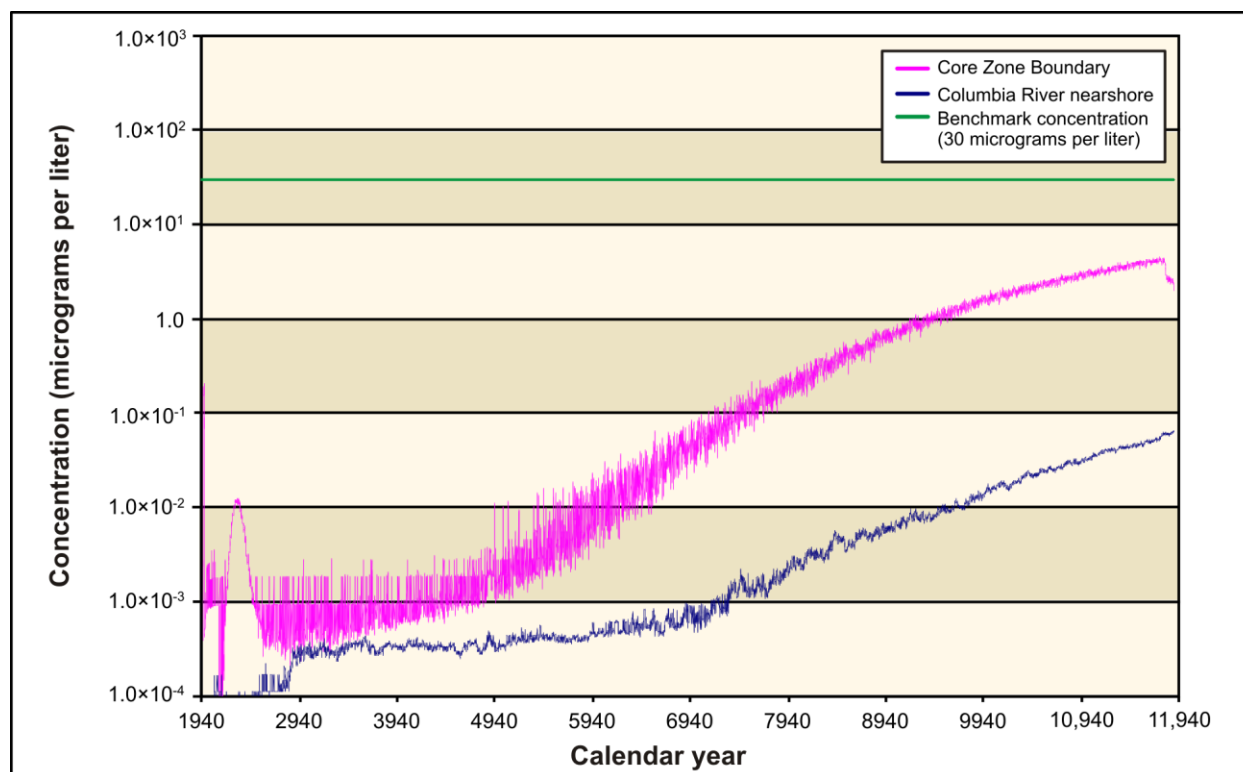
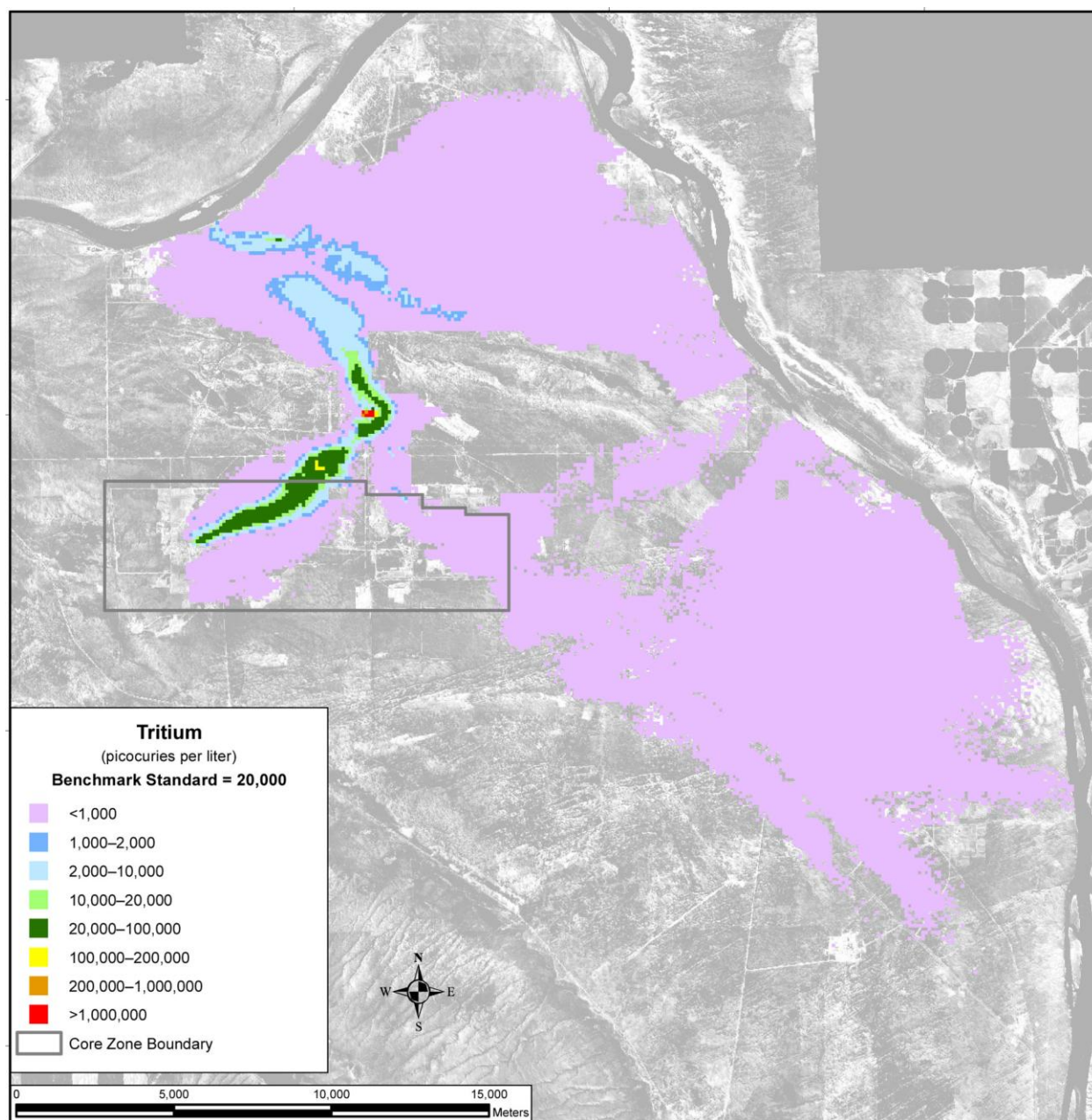


Figure 5-171. Tank Closure Alternative 5 Total Uranium Concentration Versus Time

5.1.1.8.5 Analysis of Spatial Distribution of Concentration

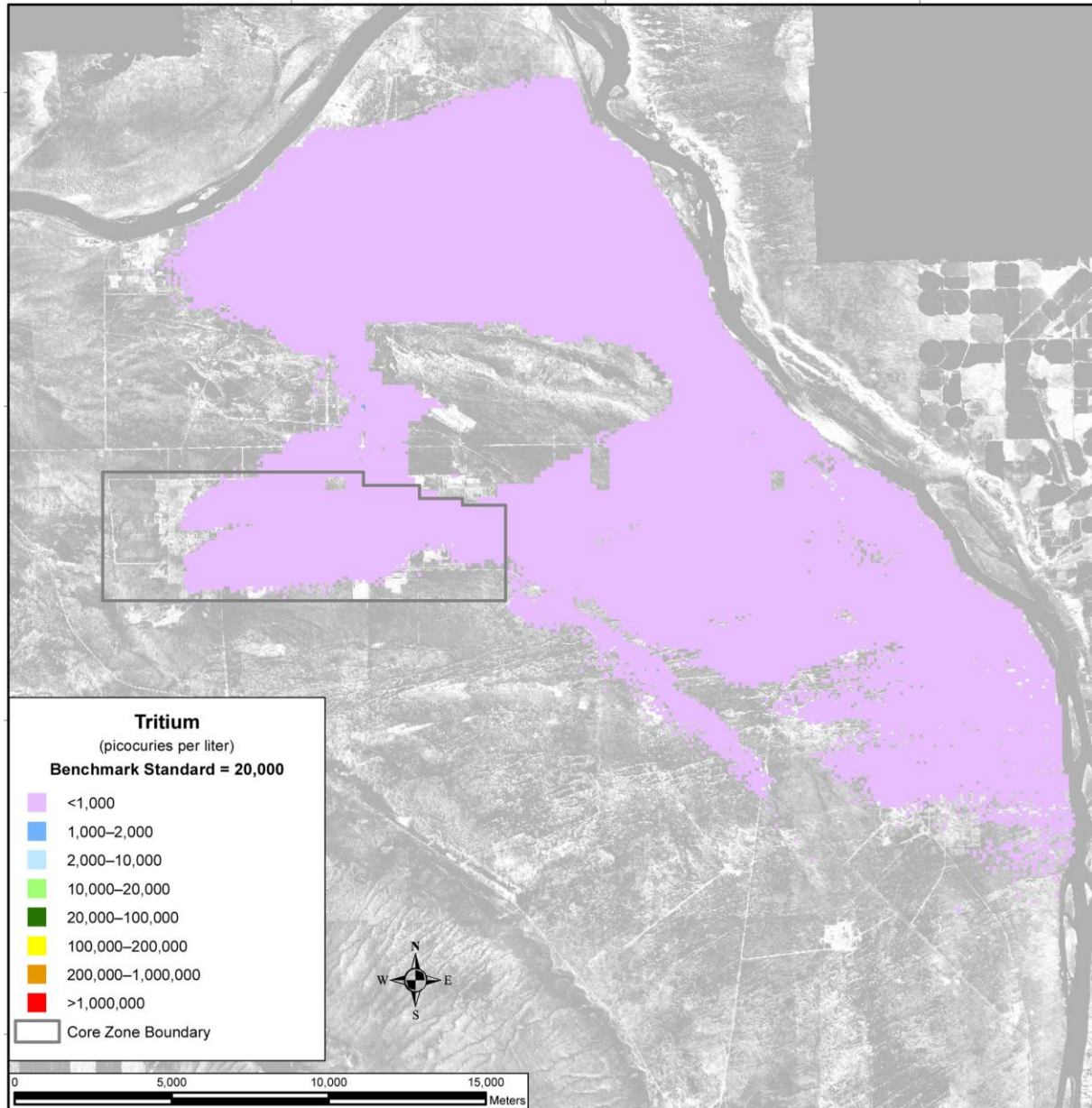
This section presents the impacts of Tank Closure Alternative 5 in terms of the spatial distribution of COPC driver concentrations in groundwater at selected times. Concentrations of radionuclides are in picocuries per liter; chemicals, in micrograms per liter (see Figures 5–172 through 5–194). Concentrations of each radionuclide and chemical are indicated by a color scale that is relative to the benchmark concentration. Concentrations greater than the benchmark concentration are indicated by the fully saturated colors green, yellow, orange, and red in order of increasing concentration. Concentrations less than the benchmark concentration are indicated by the faded colors green, blue, indigo, and violet in order of decreasing concentration. Note that the concentration ranges are on a logarithmic scale to facilitate visual comparison of concentrations that vary over three orders of magnitude.

Figure 5–172 shows the spatial distribution of tritium concentrations in groundwater in CY 2010. Releases from cribs and trenches (ditches) and past leaks, associated primarily with the T, TX, and TY tank farms, result in a groundwater concentration plume (exceeding the benchmark concentration) that extends from the center part of the 200-West Area northeast, crosses the Core Zone Boundary, and continues toward Gable Gap. Peak concentrations in this plume are about 5 to 10 times greater than the benchmark. Tritium concentrations are attenuated by radioactive decay to levels less than one-twentieth of the benchmark concentration by CY 2135 (see Figure 5–173).



Note: To convert meters to feet, multiply by 3.281.

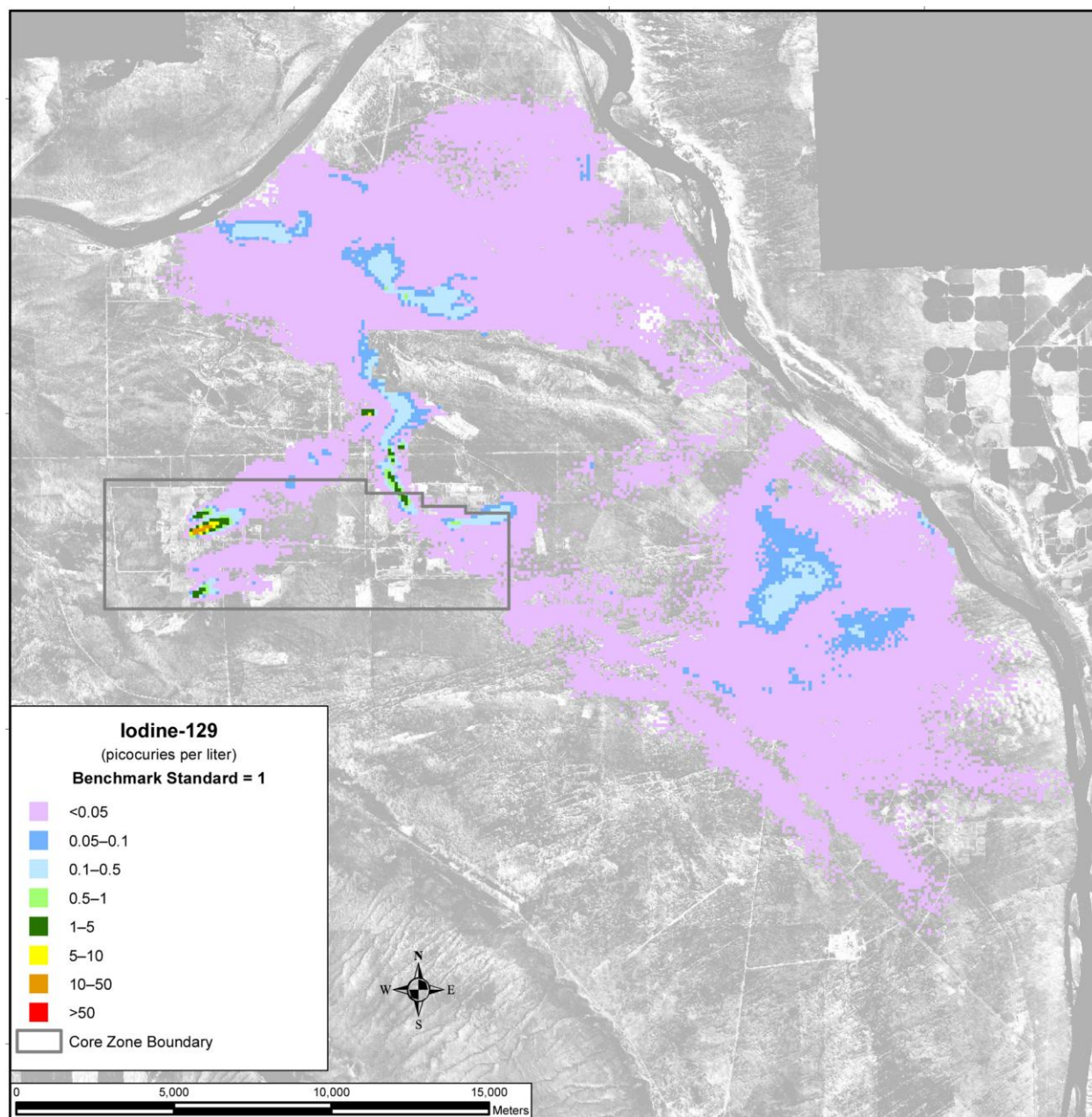
Figure 5–172. Tank Closure Alternative 5 Spatial Distribution of Groundwater Hydrogen-3 (Tritium) Concentration, Calendar Year 2010



**Figure 5–173. Tank Closure Alternative 5 Spatial Distribution of Groundwater
Hydrogen-3 (Tritium) Concentration, Calendar Year 2135**

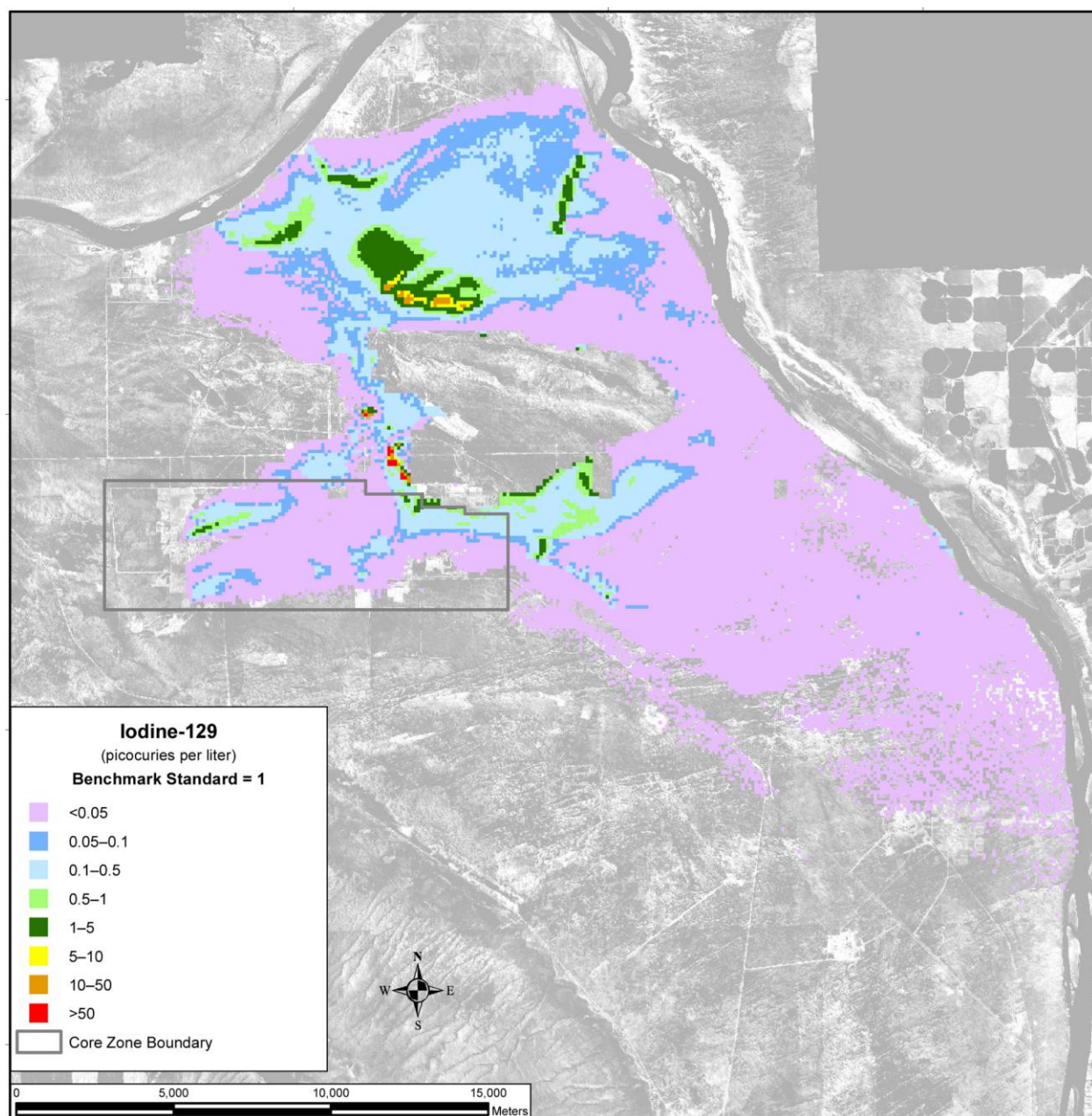
Figure 5–174 shows the spatial distribution of iodine-129 concentrations in groundwater in CY 2010. Releases from cribs and trenches (ditches) and past leaks result in groundwater concentration plumes that are at or exceed the benchmark concentration at the B, S, and T Barriers. Peak concentrations in this plume are about 10 to 50 times greater than the benchmark and are mostly contained within the Core Zone Boundary. In CY 2135, releases from other tank farm sources create a larger plume exceeding the benchmark concentration, extending north through Gable Gap and east from the A Barrier to the Columbia River (see Figure 5–175). By CY 2140, most of the mass in the plume has reached the Columbia River, with only isolated areas of high concentration, up to five times the benchmark, where the groundwater flow velocities are extremely small (see Figure 5–176). Technetium-99 (see Figures 5–177 through 5–179), chromium (see Figures 5–180 through 5–182), and nitrate (see Figure 5–183 through

5–185) show similar spatial distributions at selected times. Iodine-129, technetium-99, chromium, and nitrate are all conservative tracers (i.e., move at the rate of the pore-water velocity).



Note: To convert meters to feet, multiply by 3.281.

Figure 5–174. Tank Closure Alternative 5 Spatial Distribution of Groundwater Iodine-129 Concentration, Calendar Year 2010



**Figure 5–175. Tank Closure Alternative 5 Spatial Distribution of Groundwater
Iodine-129 Concentration, Calendar Year 2135**

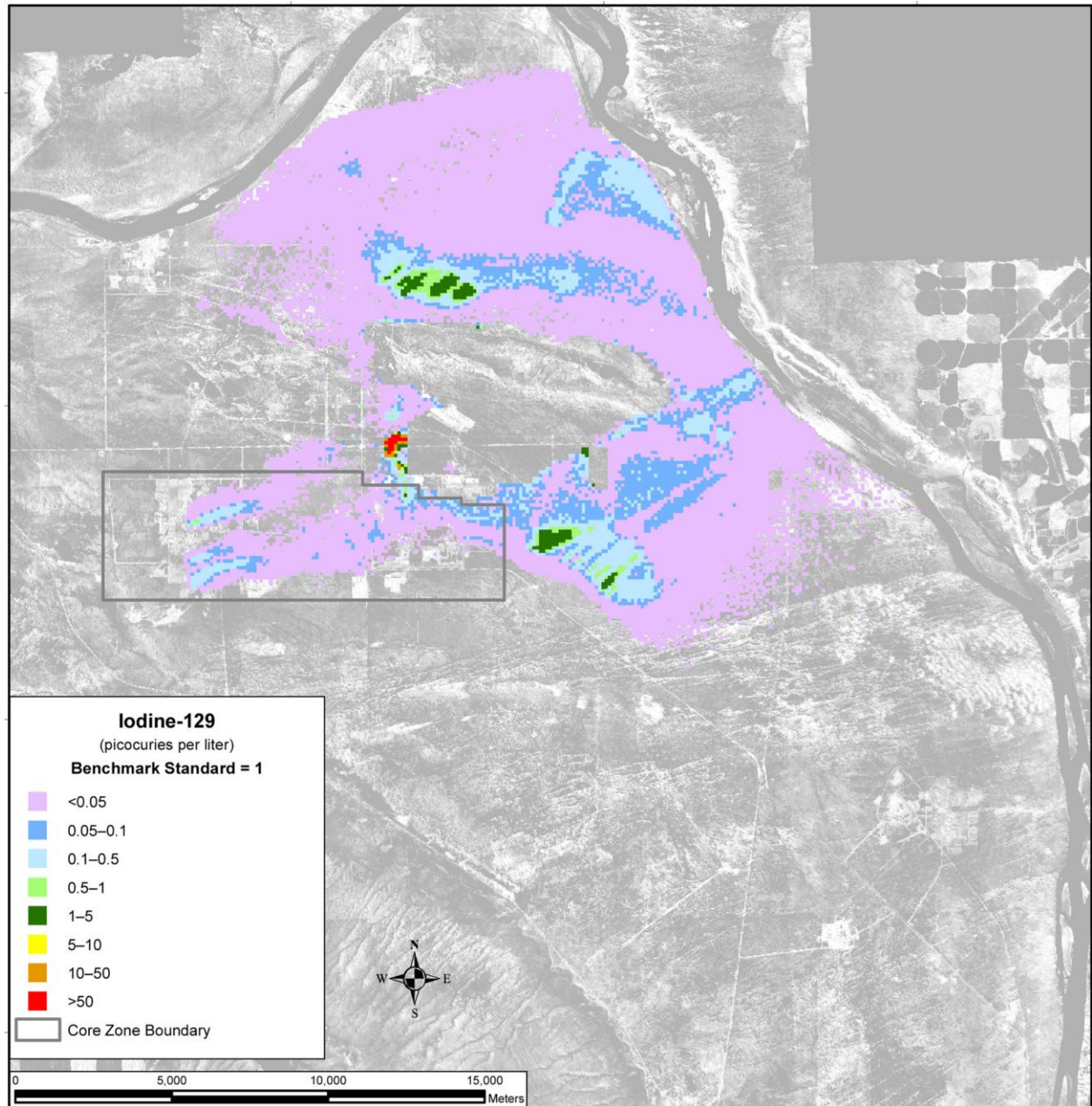
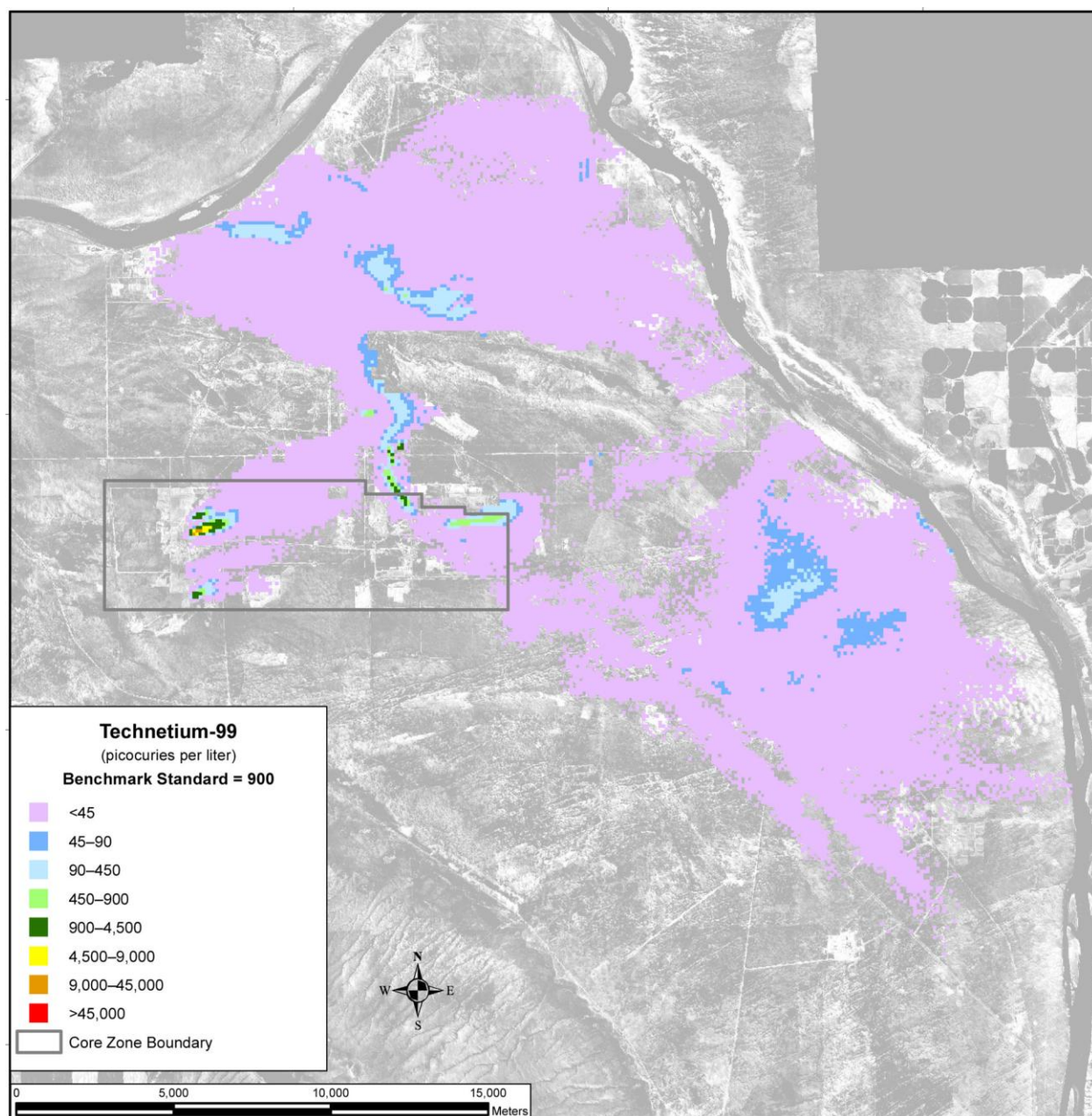
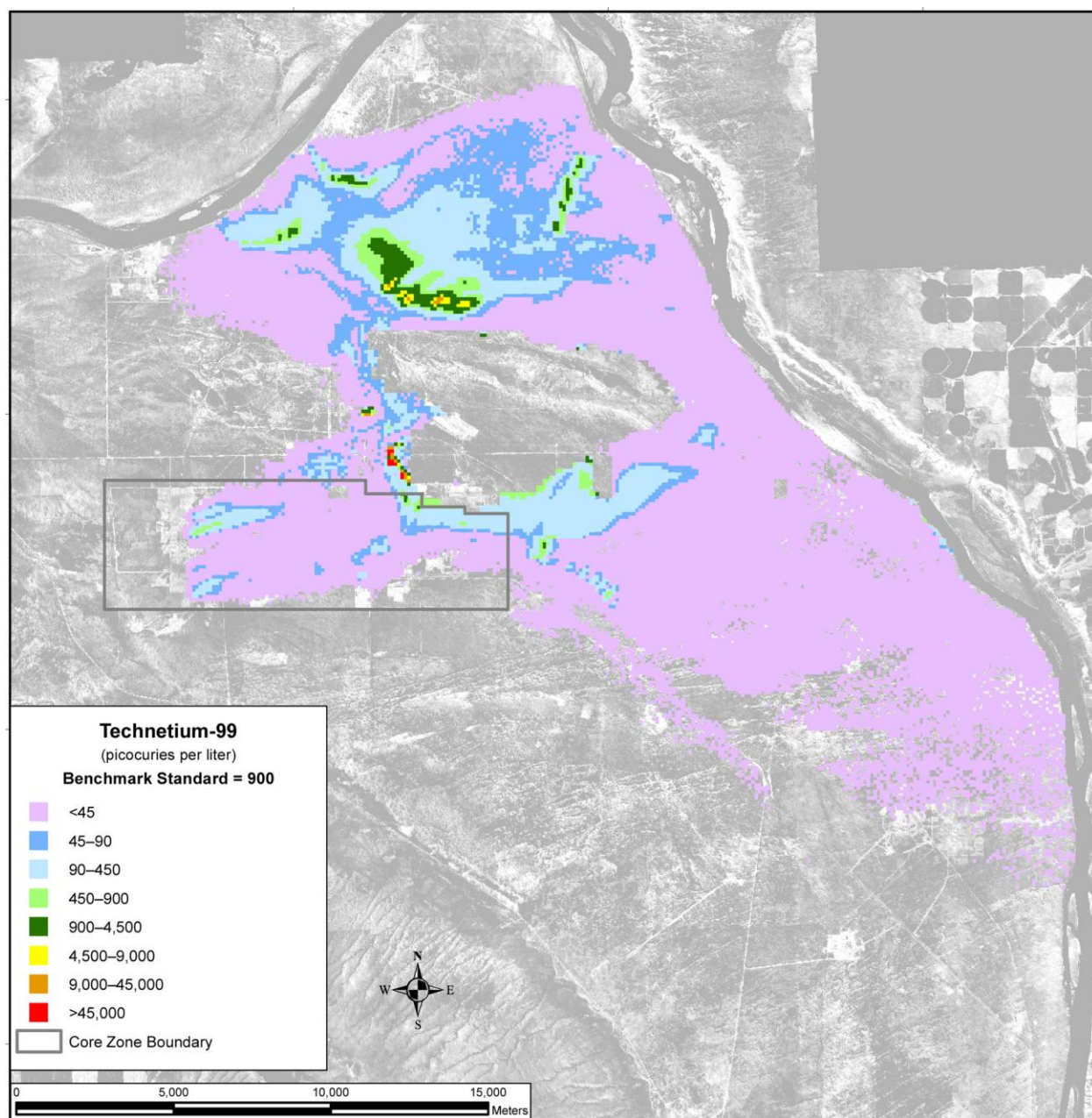


Figure 5–176. Tank Closure Alternative 5 Spatial Distribution of Groundwater Iodine-129 Concentration, Calendar Year 7140



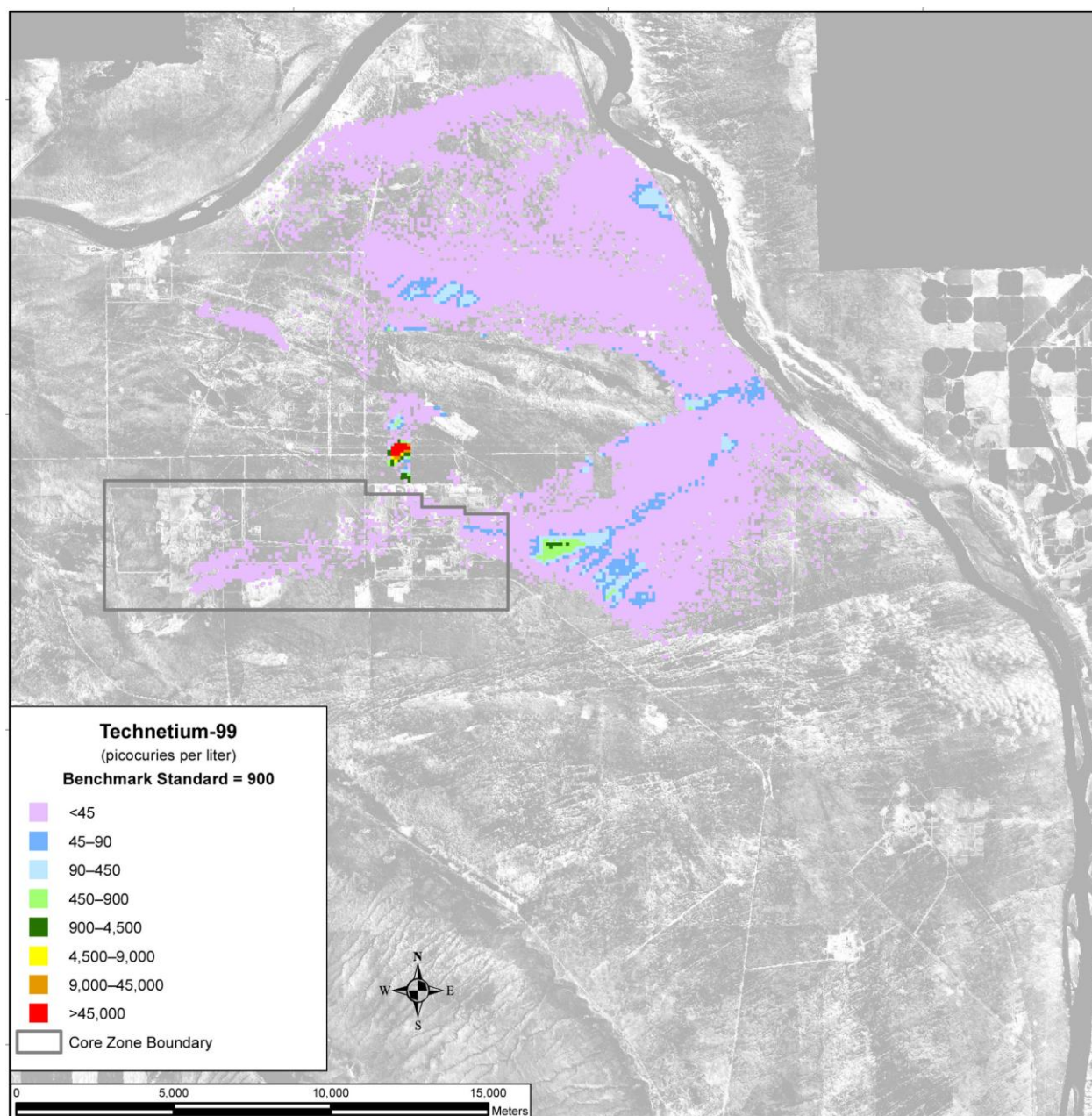
Note: To convert meters to feet, multiply by 3.281.

**Figure 5-177. Tank Closure Alternative 5 Spatial Distribution of Groundwater
Technetium-99 Concentration, Calendar Year 2010**

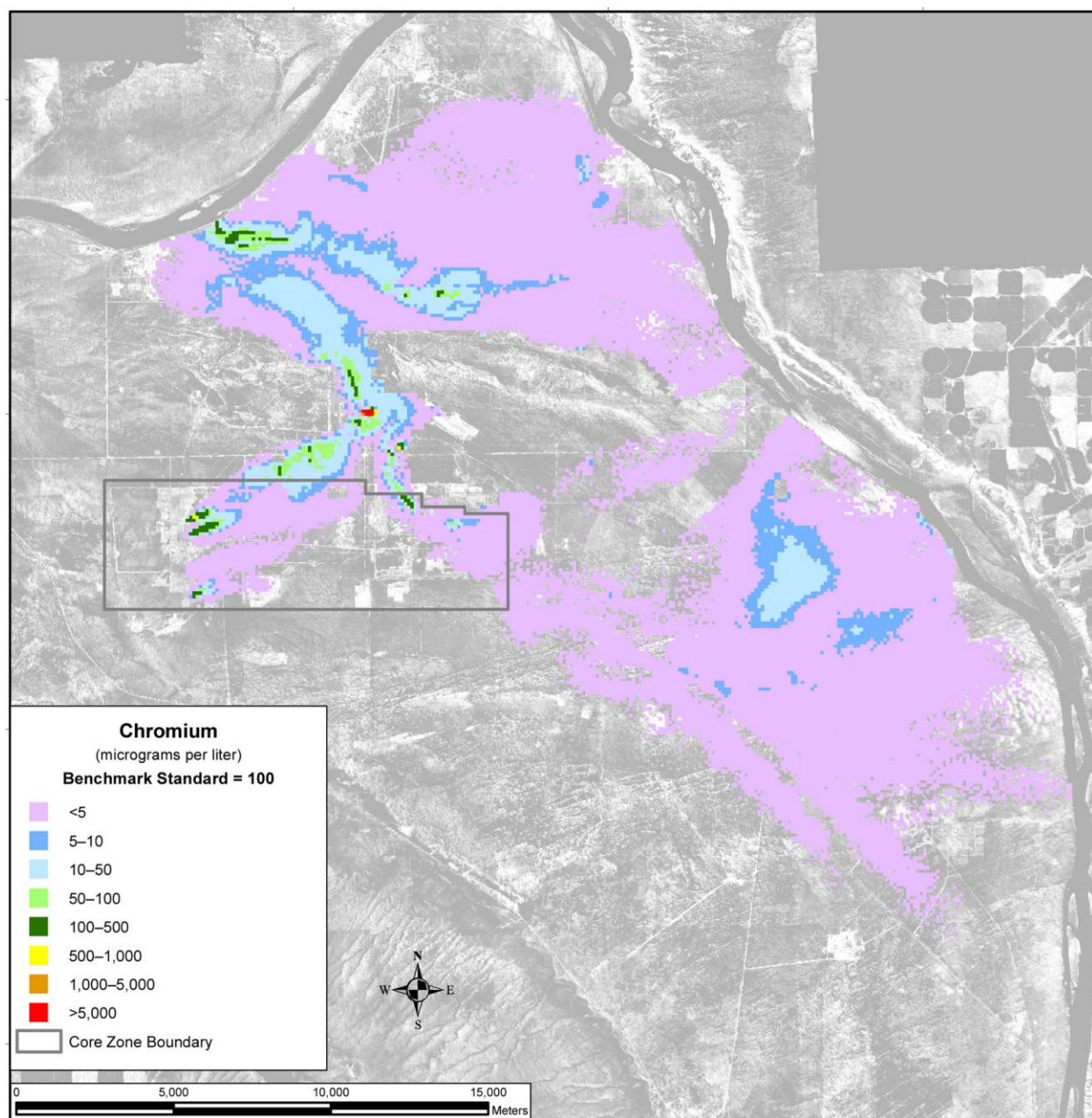


Note: To convert meters to feet, multiply by 3.281.

Figure 5-178. Tank Closure Alternative 5 Spatial Distribution of Groundwater Technetium-99 Concentration, Calendar Year 2135

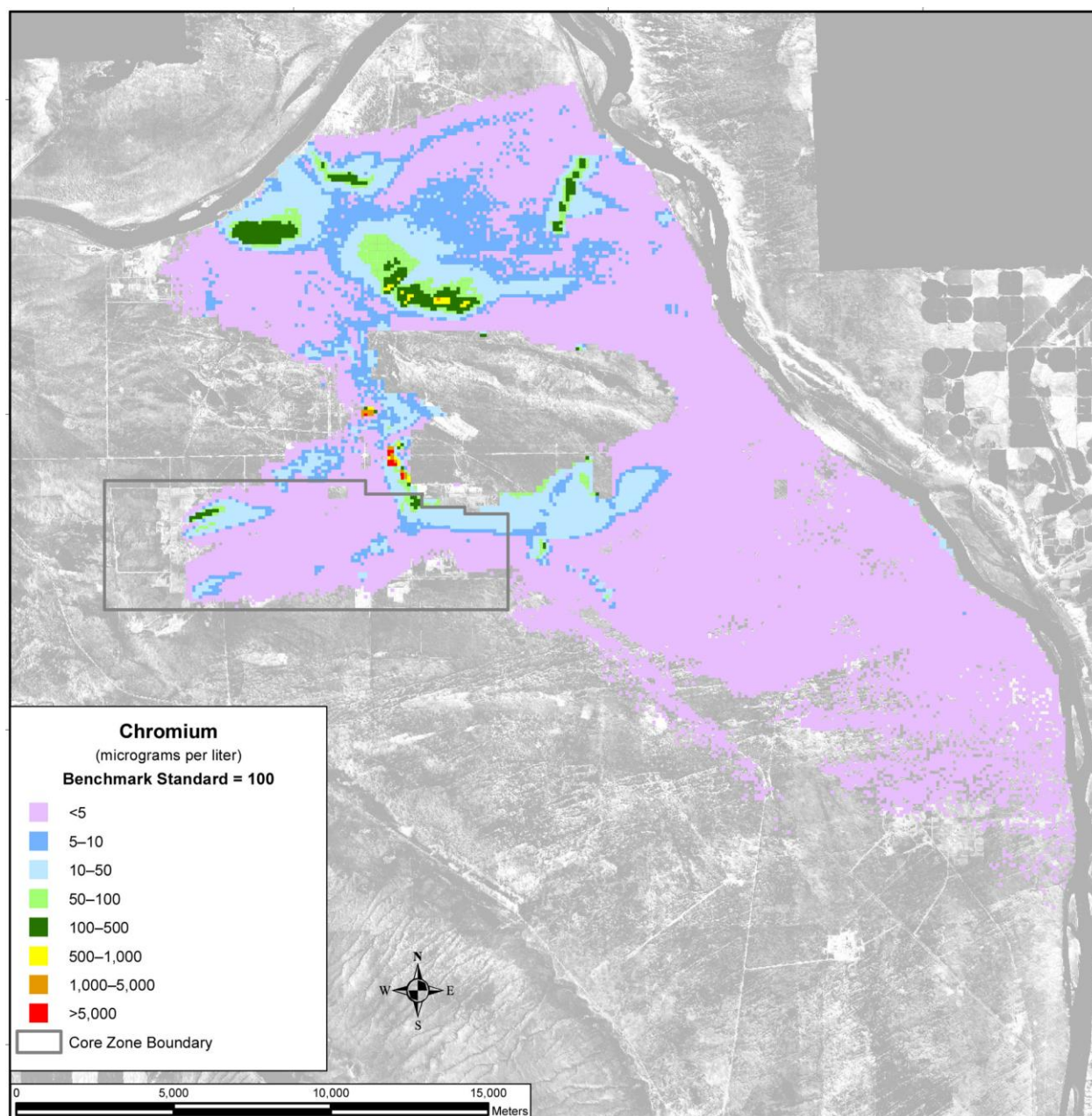


**Figure 5–179. Tank Closure Alternative 5 Spatial Distribution of Groundwater
Technetium-99 Concentration, Calendar Year 7140**



Note: To convert meters to feet, multiply by 3.281.

Figure 5–180. Tank Closure Alternative 5 Spatial Distribution of Groundwater Chromium Concentration, Calendar Year 2010



**Figure 5–181. Tank Closure Alternative 5 Spatial Distribution of Groundwater
Chromium Concentration, Calendar Year 2135**

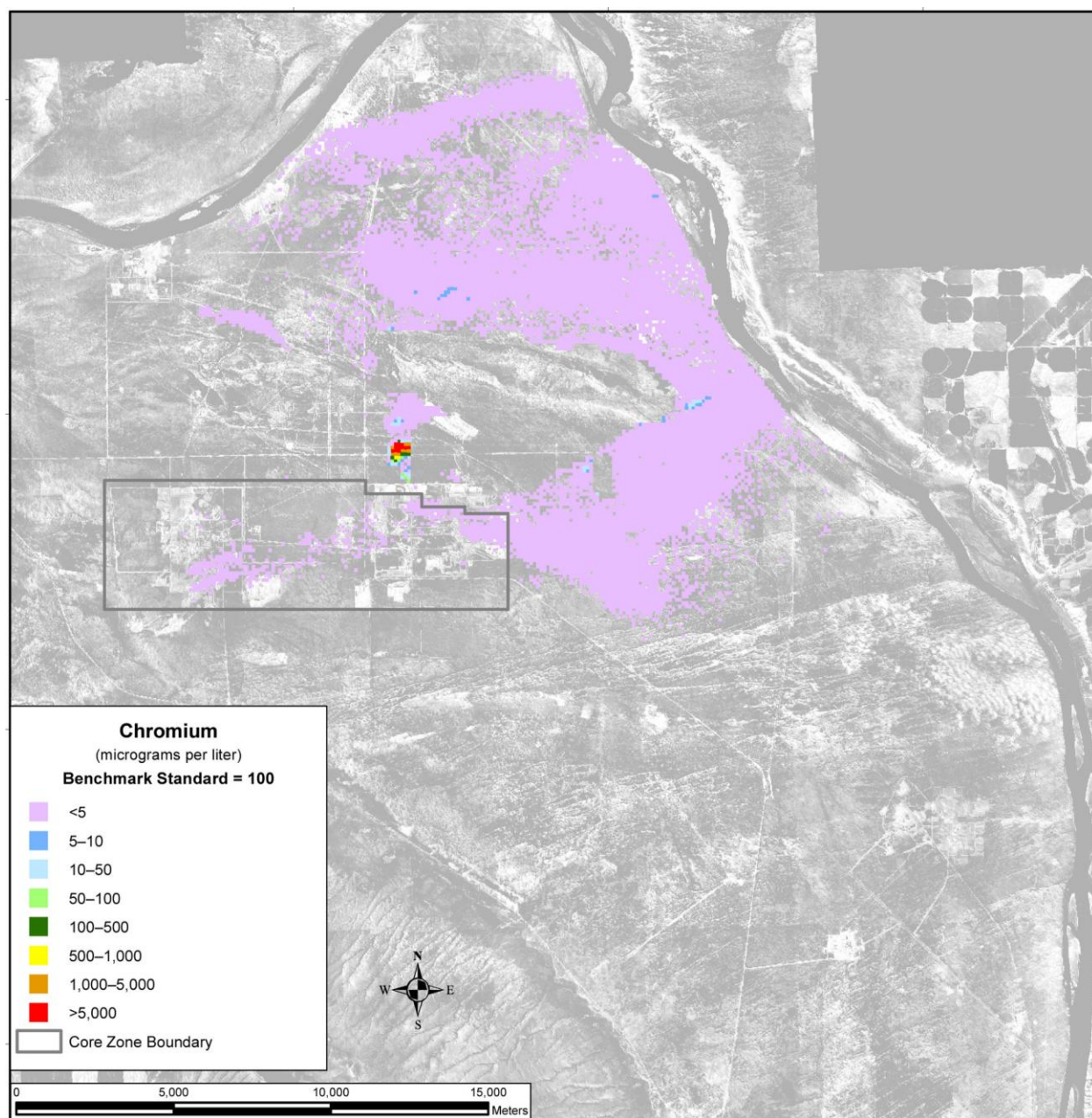
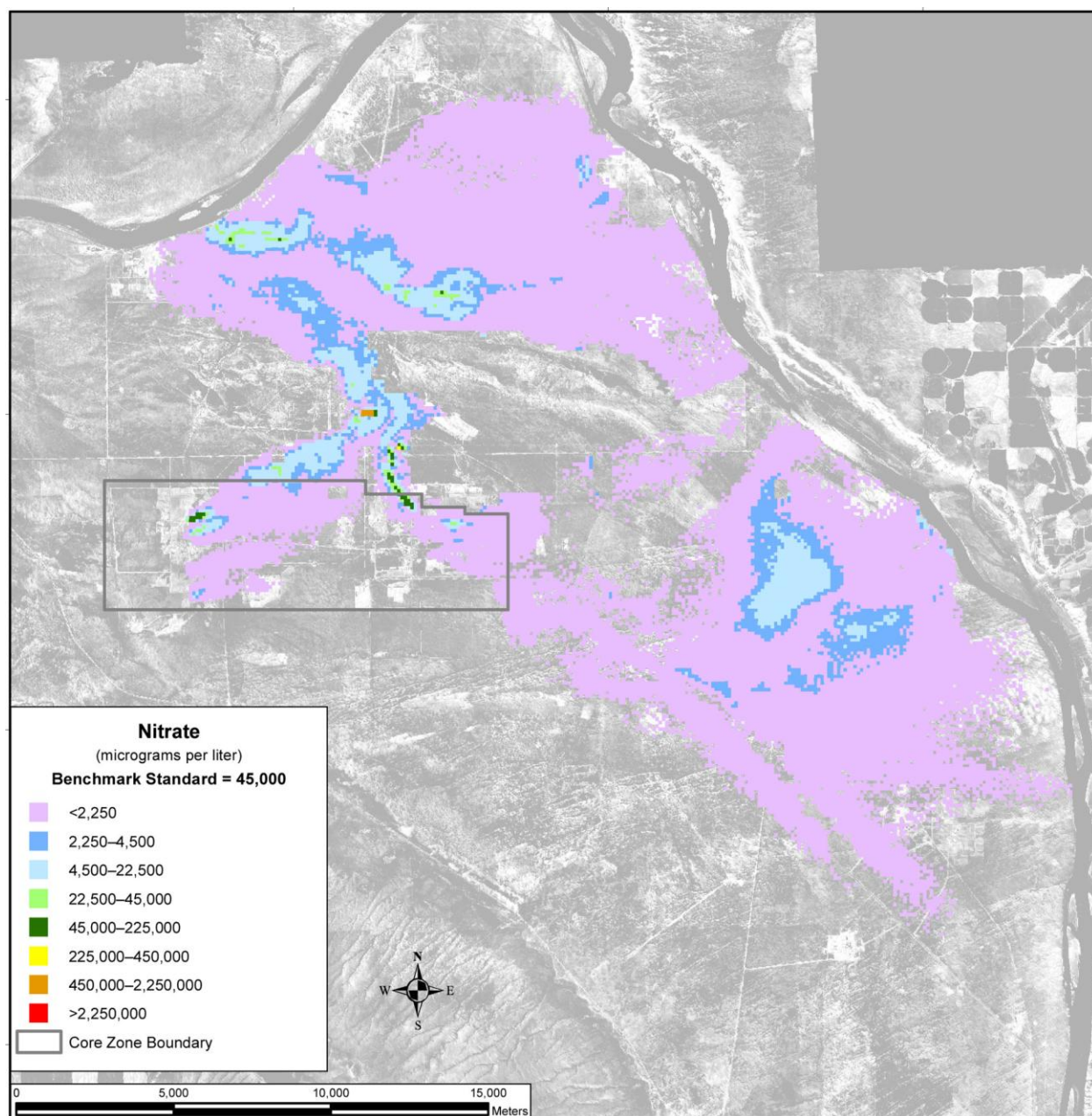
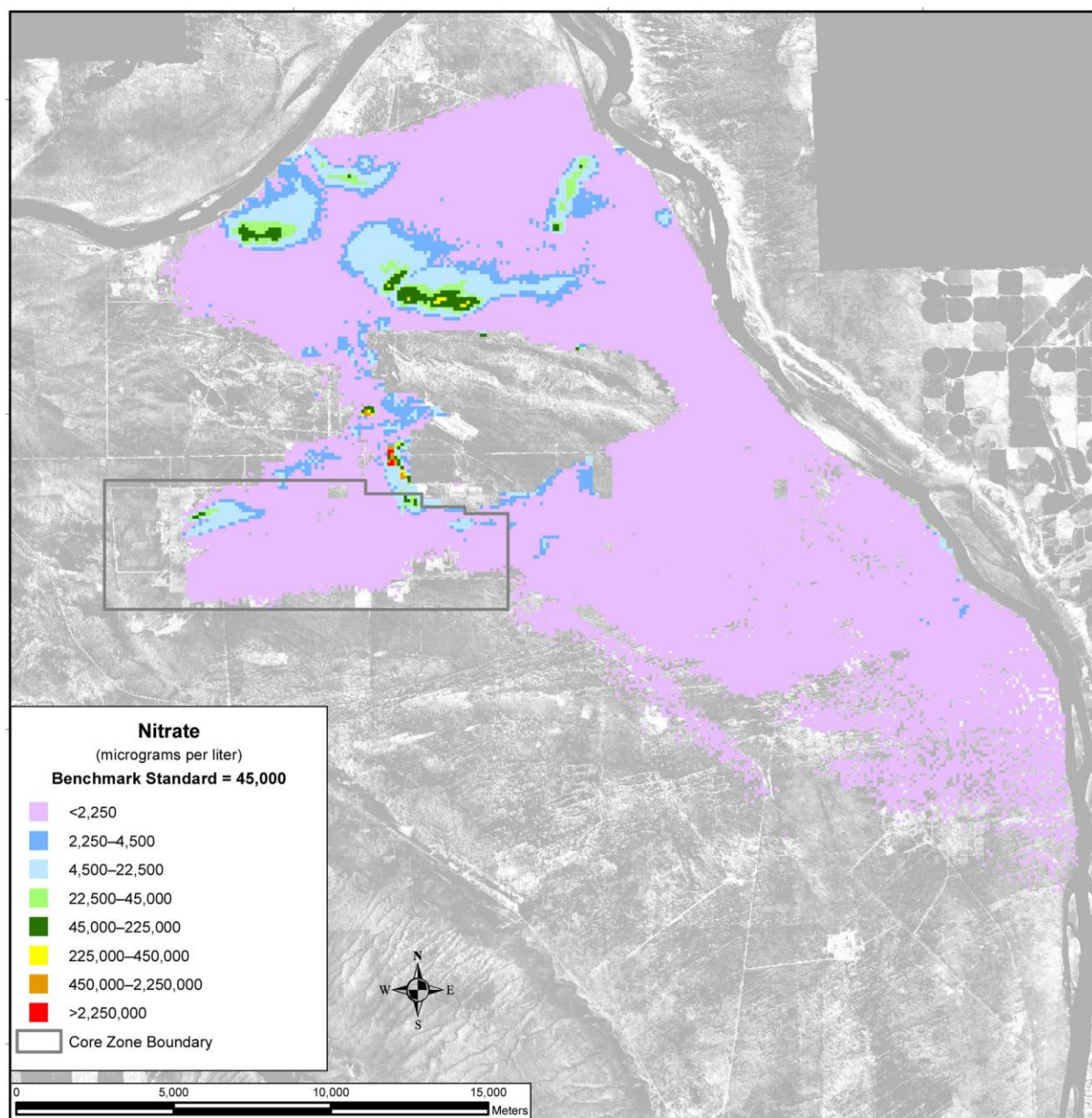


Figure 5–182. Tank Closure Alternative 5 Spatial Distribution of Groundwater Chromium Concentration, Calendar Year 7140



**Figure 5–183. Tank Closure Alternative 5 Spatial Distribution of Groundwater
Nitrate Concentration, Calendar Year 2010**



Note: To convert meters to feet, multiply by 3.281.

Figure 5–184. Tank Closure Alternative 5 Spatial Distribution of Groundwater Nitrate Concentration, Calendar Year 2135

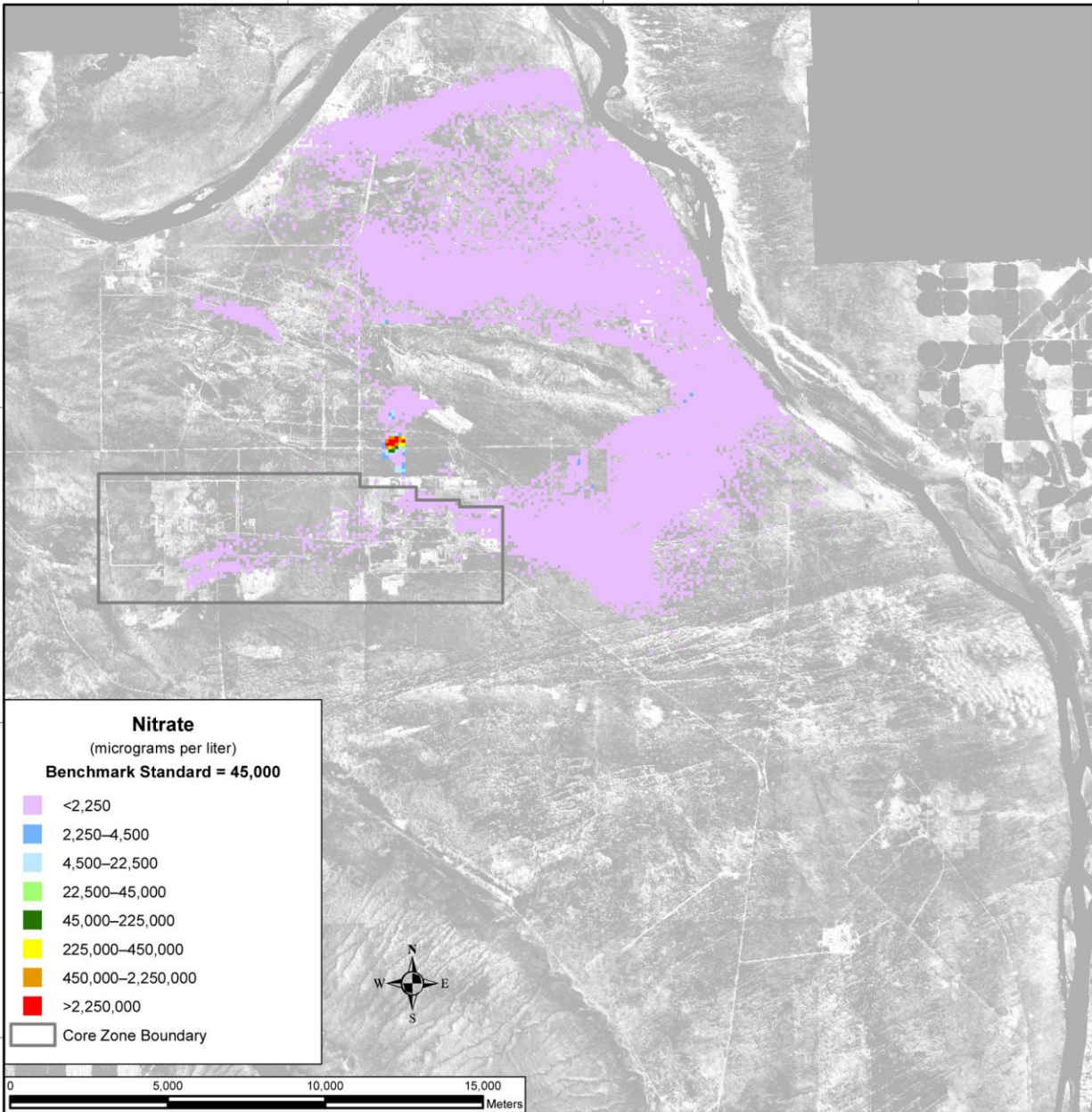
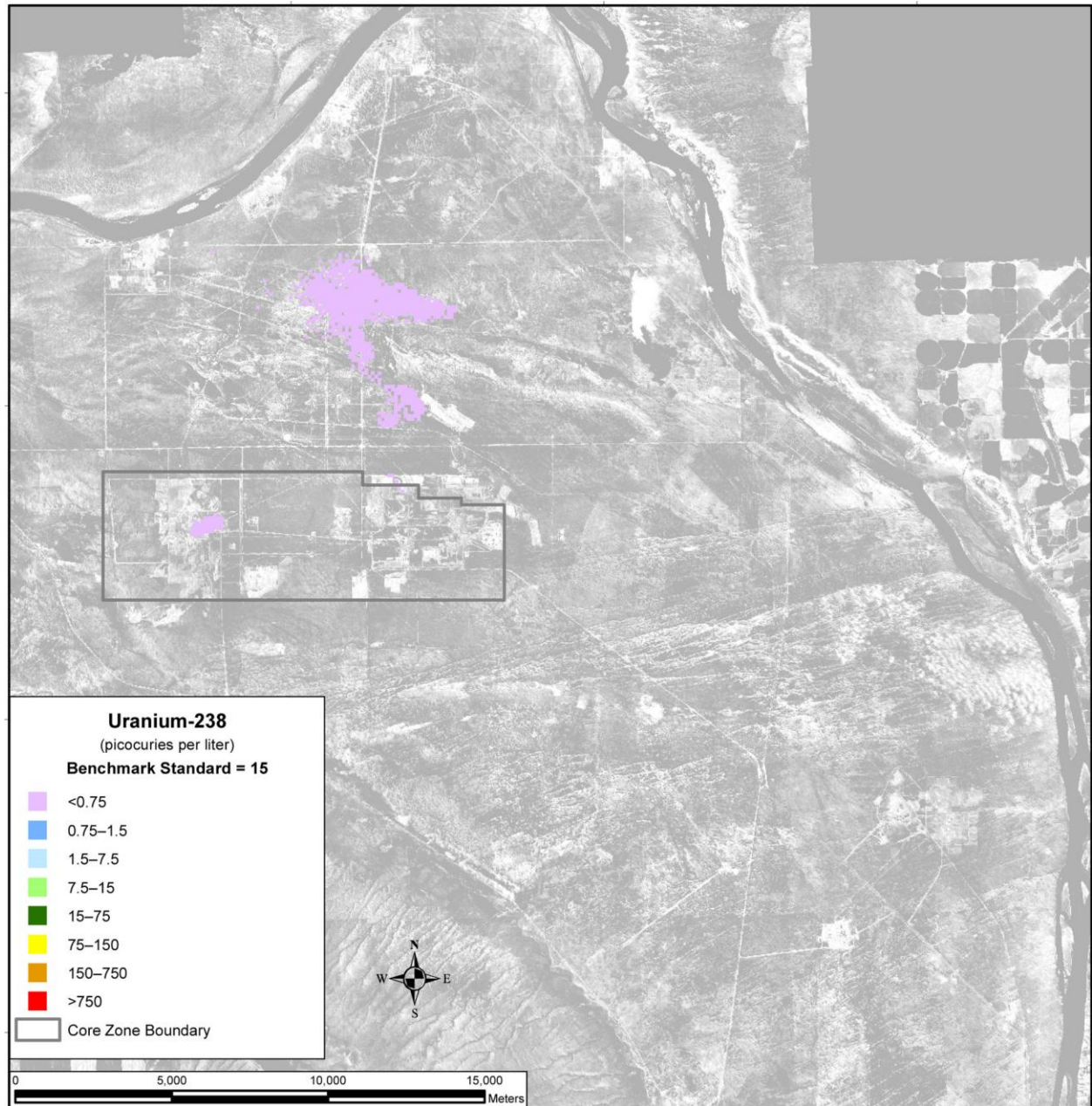


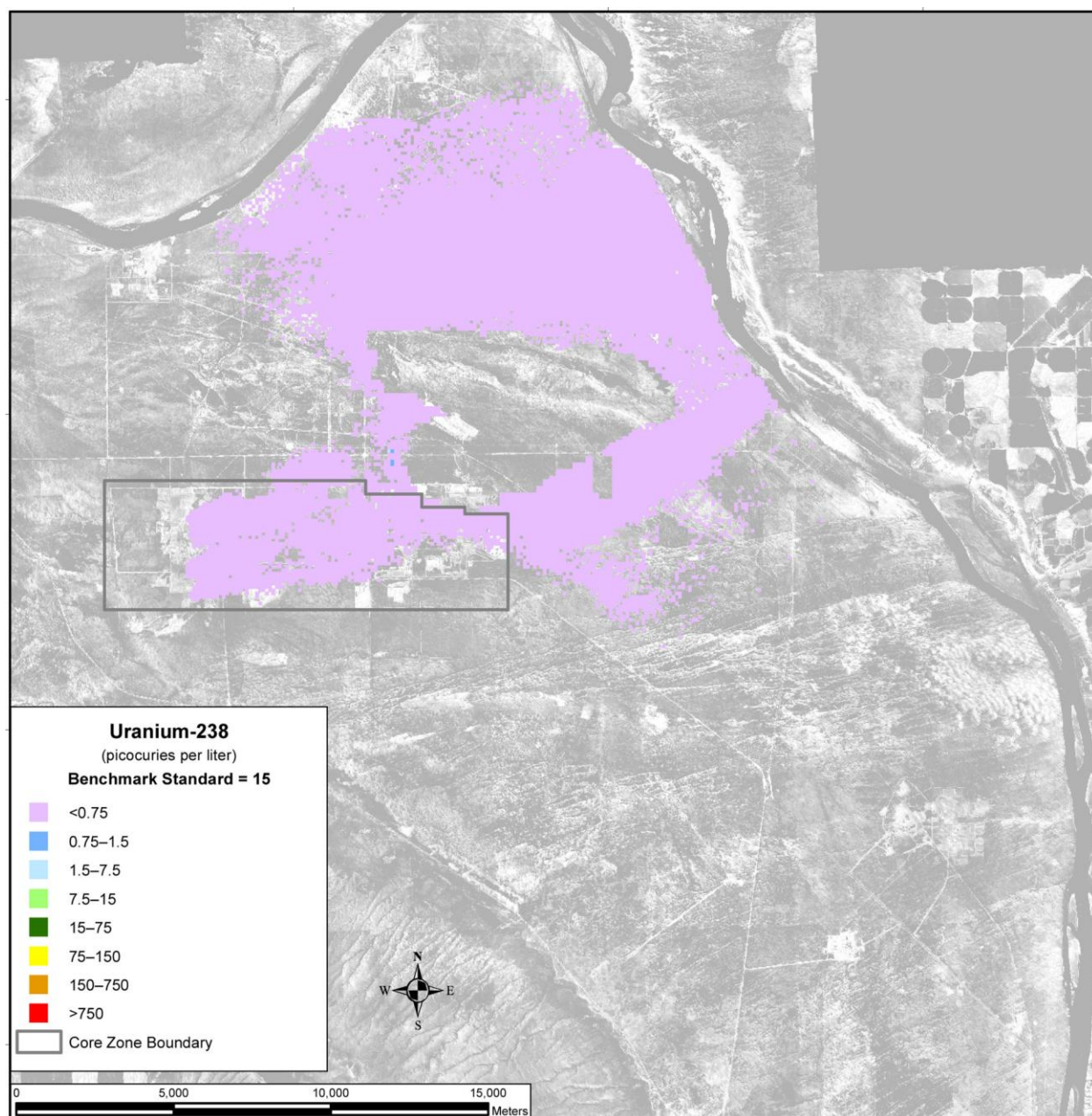
Figure 5–185. Tank Closure Alternative 5 Spatial Distribution of Groundwater Nitrate Concentration, Calendar Year 7140

Uranium-238 and total uranium show a different spatial distribution in the analysis over time. These COPCs are not as mobile as those discussed above, moving about seven times more slowly than the pore-water velocity. As a result, travel times through the vadose zone are longer, release to the aquifer is delayed, and travel times through the aquifer to the Columbia River are longer. Figure 5–186 shows the distribution of uranium-238 in CY 2010. There is a small plume associated with releases from cribs and trenches (ditches) and past leaks at the T Barrier that is less than one-twentieth of the benchmark concentration. The plume extends northeast through Gable Gap. By CY 7140 (see Figure 5–187), the area of the plume has grown, but there are no significant increases in peak concentration. In CY 11,940 (see Figure 5–188), the greatest development of the plume during the analysis period is seen, resulting primarily from the release of other tank farm sources at the A and B Barriers. Figures 5–189 through 5–191 show the corresponding results for total uranium.

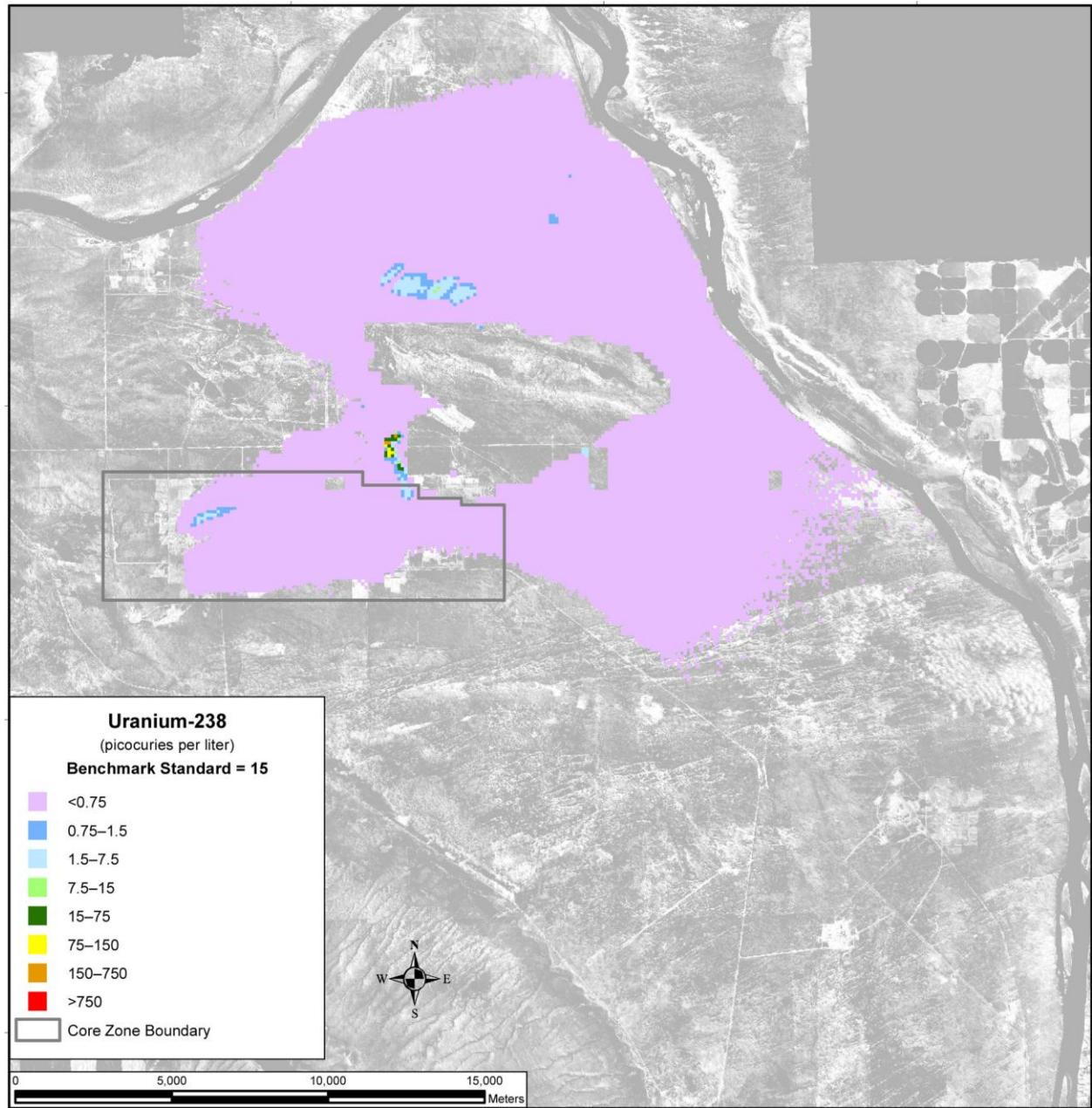


Note: To convert meters to feet, multiply by 3.281.

Figure 5–186. Tank Closure Alternative 5 Spatial Distribution of Groundwater Uranium-238 Concentration, Calendar Year 2010

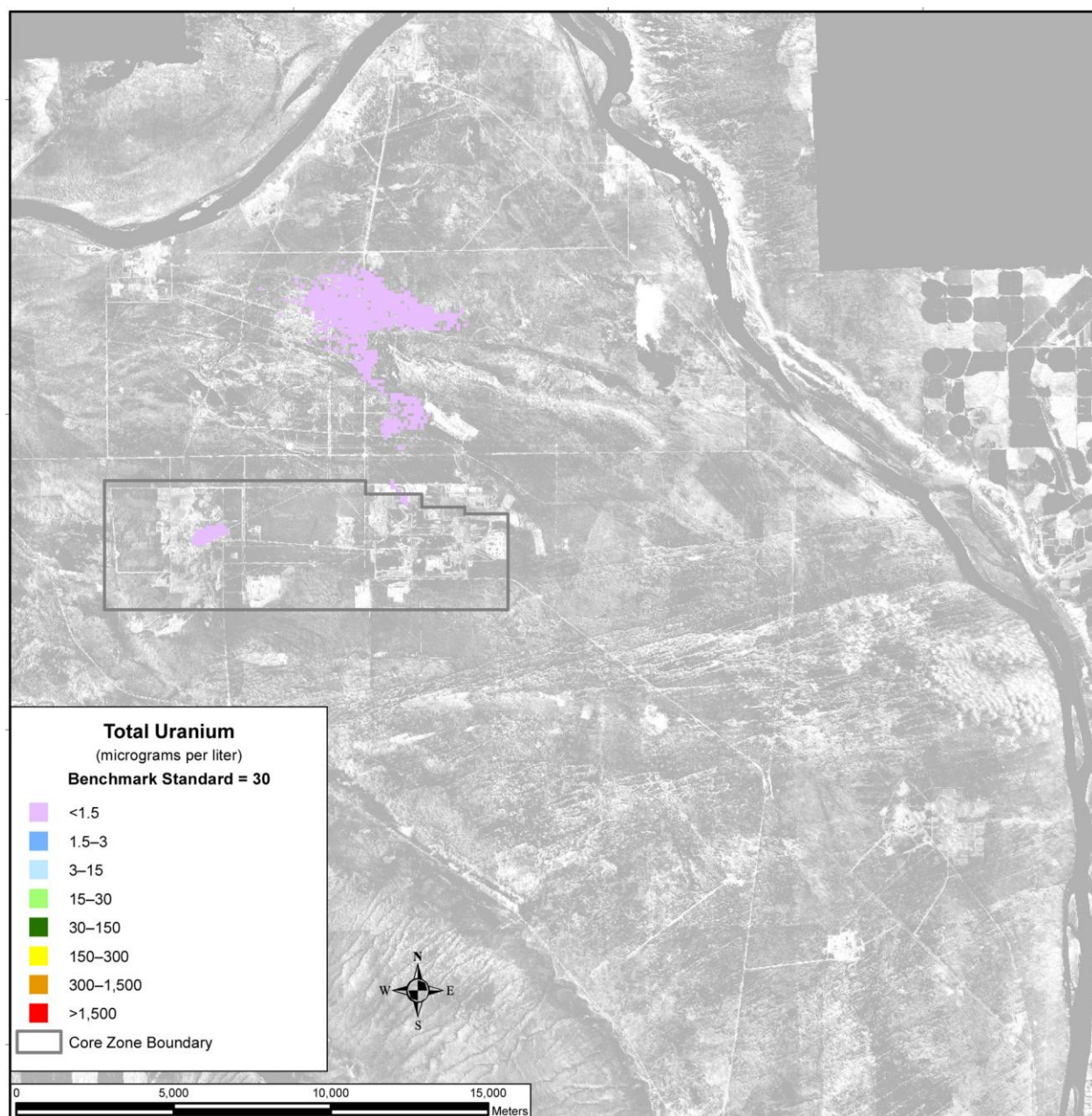


**Figure 5–187. Tank Closure Alternative 5 Spatial Distribution of Groundwater
Uranium-238 Concentration, Calendar Year 7140**

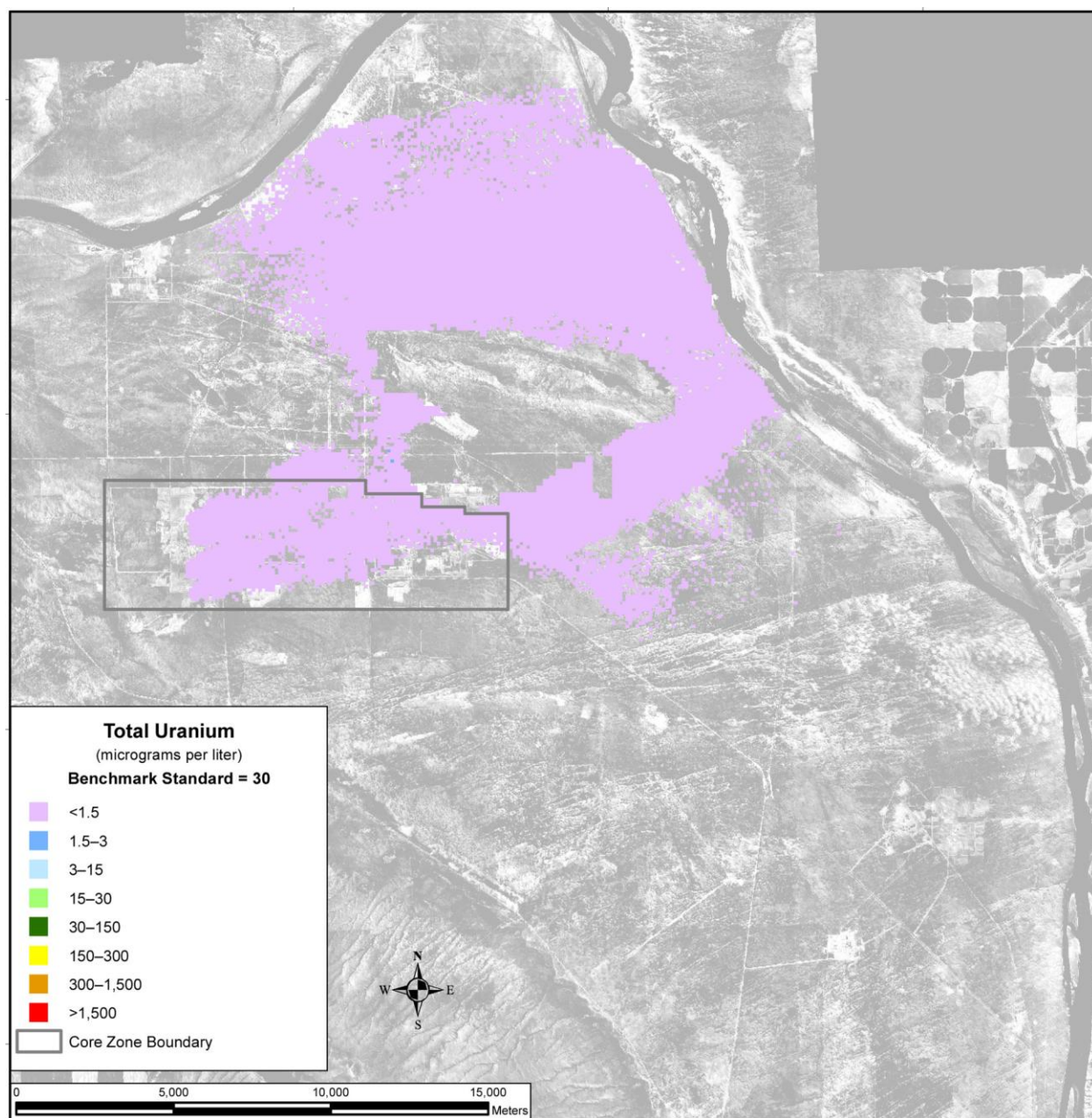


Note: To convert meters to feet, multiply by 3.281.

Figure 5–188. Tank Closure Alternative 5 Spatial Distribution of Groundwater Uranium-238 Concentration, Calendar Year 11,940

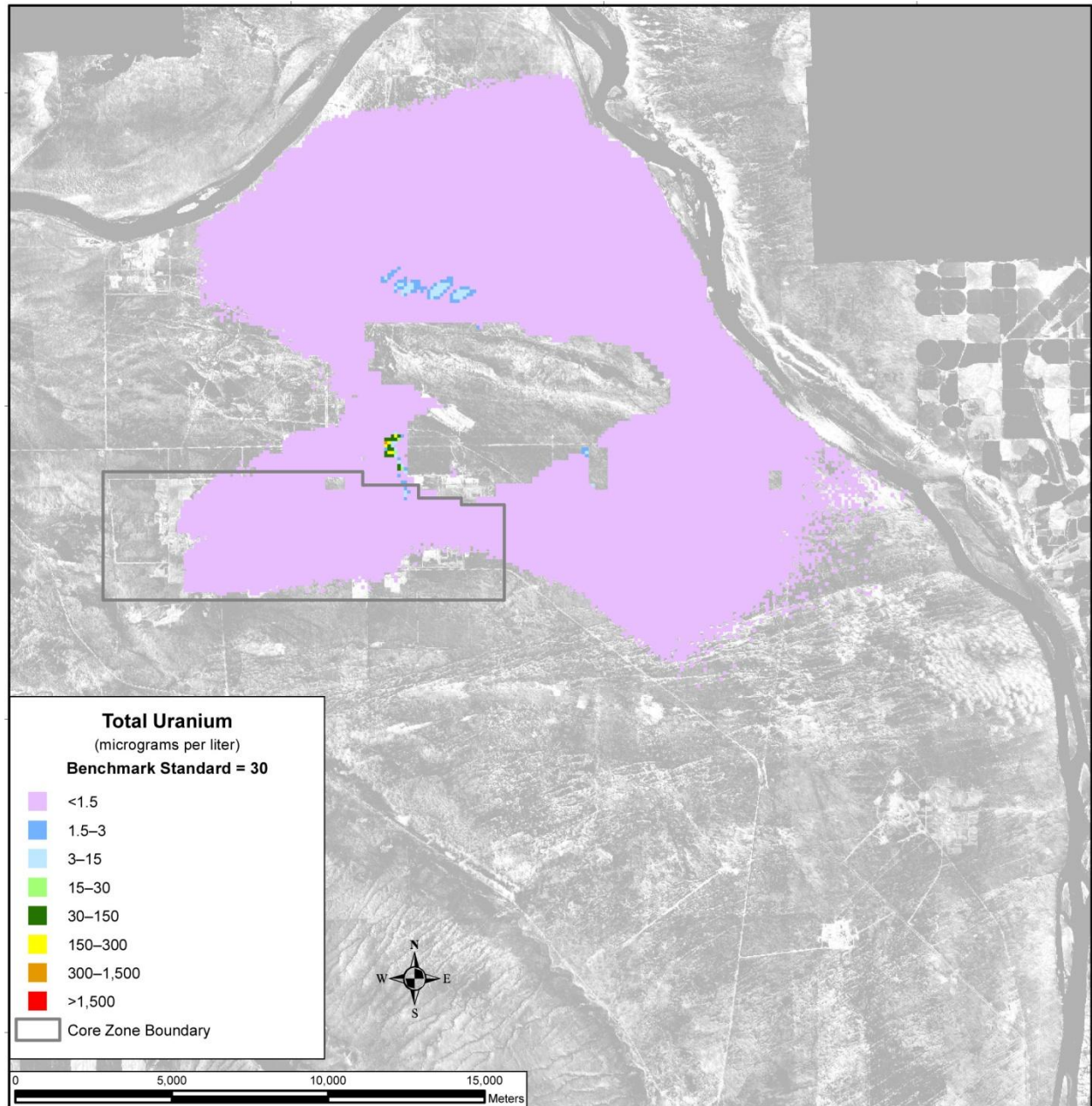


**Figure 5–189. Tank Closure Alternative 5 Spatial Distribution of Groundwater
Total Uranium Concentration, Calendar Year 2010**



Note: To convert meters to feet, multiply by 3.281.

Figure 5–190. Tank Closure Alternative 5 Spatial Distribution of Groundwater Total Uranium Concentration, Calendar Year 7140



**Figure 5–191. Tank Closure Alternative 5 Spatial Distribution of Groundwater
Total Uranium Concentration, Calendar Year 11,940**

Figures 5–192 through 5–194 show the area in which groundwater iodine-129, technetium-99, and uranium-238 concentrations exceed their respective benchmark concentrations. Iodine-129 peaks early in the simulation, covering a peak area of just over 7 square kilometers (2.7 square miles) around CY 2100. This area drops below 1 square kilometer (0.4 square miles) by CY 3490. The plume then rises to about 3 square kilometers (1.2 square miles) in CY 4740, after which it declines to around 1 square kilometer (0.4 square miles) by CY 11,890. Technetium-99 shows a similar, more gradual trend, peaking at over 4 square kilometers (1.5 square miles) in CY 2100 and decreasing to less than 1 square kilometer (0.4 square miles) in CY 2890. The plume then increases to greater than 9 square kilometers (3.5 square miles) in CY 4440, declines rapidly to around 2 square kilometers (0.77 square miles), and finally levels off to around 0.3 square kilometers (0.001 square miles) by CY 11,890. Uranium-238 shows a distinctly

different pattern, without any area above the benchmark concentration until CY 8390. From CY 8390 until the end of the simulation, areas in which uranium-238 concentrations exceed the benchmark concentration slowly increase to about 0.24 square kilometers (0.1 square miles).

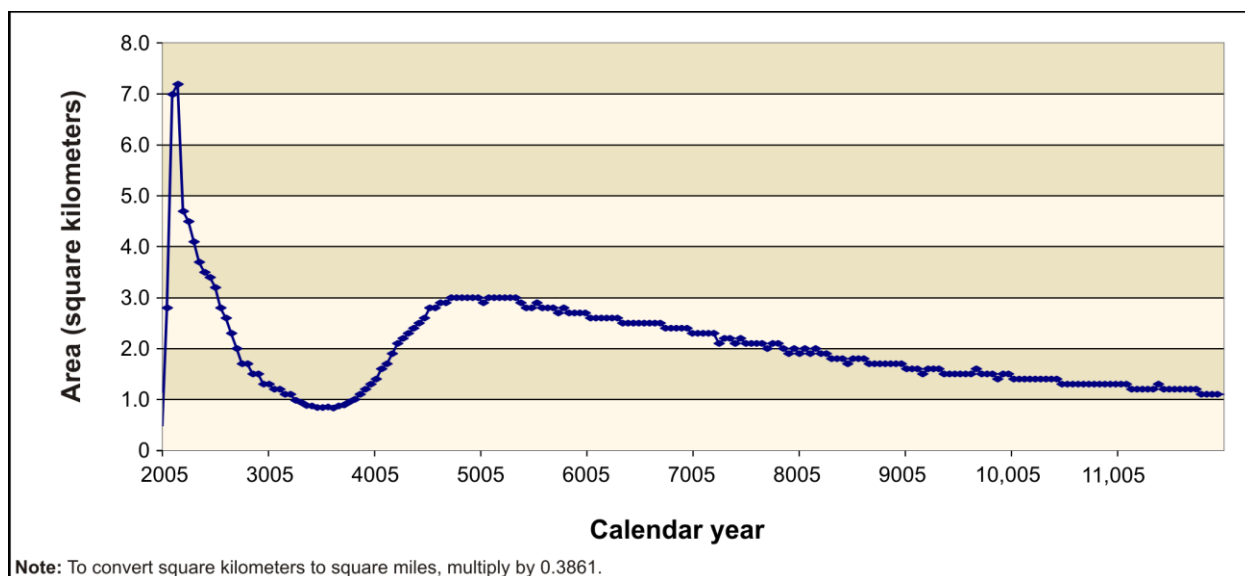


Figure 5–192. Tank Closure Alternative 5 Total Area of Groundwater Iodine-129 Concentration Exceeding the Benchmark Concentration as a Function of Time

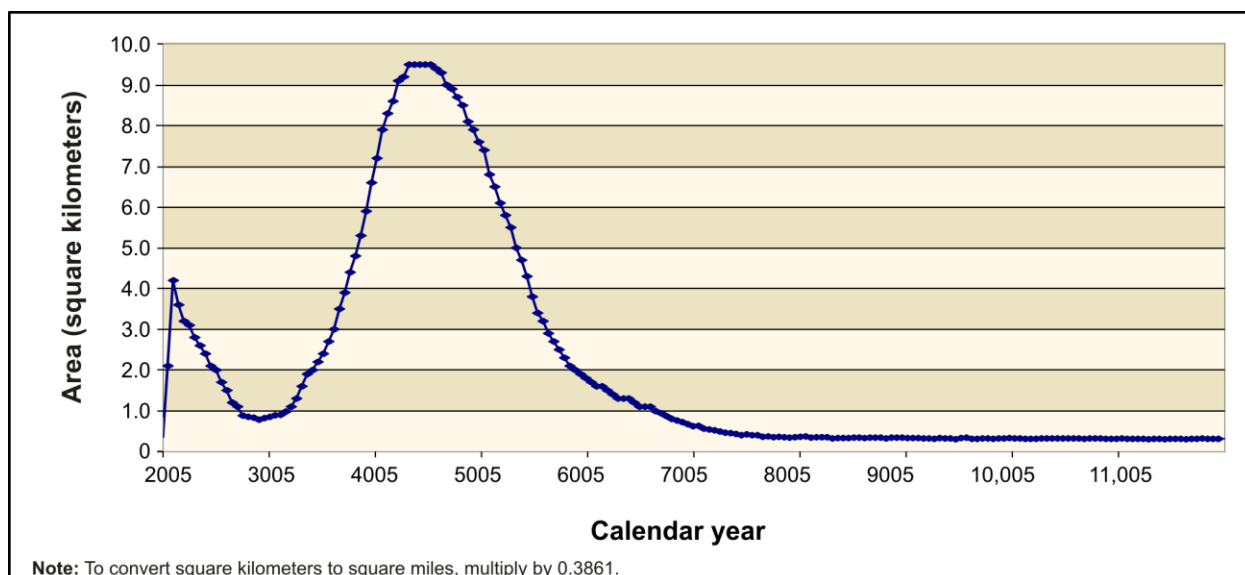


Figure 5–193. Tank Closure Alternative 5 Total Area of Groundwater Technetium-99 Concentration Exceeding the Benchmark Concentration as a Function of Time

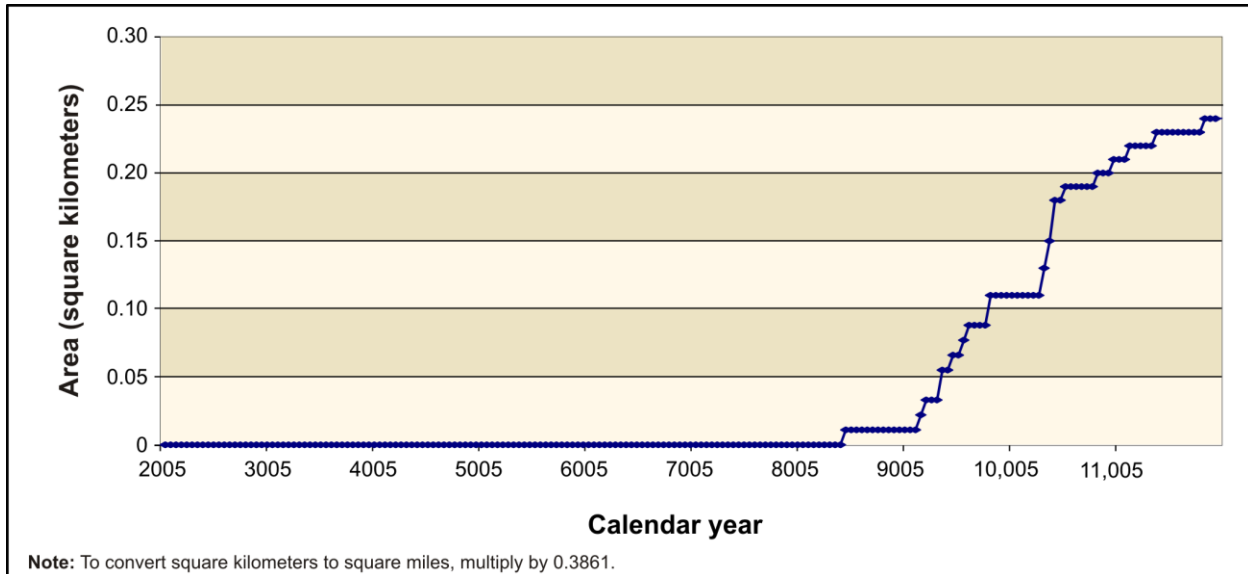


Figure 5-194. Tank Closure Alternative 5 Total Area of Groundwater Uranium-238 Concentration Exceeding the Benchmark Concentration as a Function of Time

5.1.1.8.6 Summary of Impacts

Under Tank Closure Alternative 5, concentrations of the conservative tracers at the Core Zone Boundary exceed benchmark standards by two to three orders of magnitude during the early part of the period of analysis. Tank farm residuals result in concentration peaks that exceed the benchmark concentrations early in the post-administrative control period and then continuously decline until the end of the 10,000-year analysis period. Concentrations of conservative tracers at the Columbia River nearshore approach the benchmark for a short time during the early period of analysis, but fall below the benchmark for the remainder of the period of analysis. The intensities and areas of these groundwater plumes peak around CY 2100 for iodine-129 and around CY 4440 for technetium-99.

Concentrations of tritium at the Core Zone Boundary exceed the benchmark by about one to two orders of magnitude during the first 100 years of the period of analysis. Tritium concentrations at the Columbia River nearshore approach the benchmark during this time. Attenuation by radioactive decay is a predominant mechanism that limits the intensity and duration of groundwater impacts of tritium. After CY 2100, tritium impacts are essentially negligible.

For uranium-238 and total uranium, limited mobility is an important factor governing the timeframes and scale of groundwater impacts. The concentrations of these retarded species never exceed the benchmark concentration at the Core Zone Boundary or the Columbia River nearshore. The intensity is highest and the area of the contamination plume largest near the end of the period of analysis.

5.1.1.9 Tank Closure Alternative 6A: All Vitrification/No Separations; Clean Closure, Base and Option Cases

This section describes the groundwater analysis results for Tank Closure Alternative 6A, including long-term groundwater impacts of sources within the tank farm barriers. Impacts of sources removed from within the tank farm barriers and disposed of in an IDF and the RPPDF are presented in Section 5.3, which discusses waste management impacts.

Under Tank Closure Alternative 6A, Base Case, tank waste would be retrieved to a volume corresponding to 99.9 percent retrieval; all tank farms would be clean closed by removing the tanks, ancillary

equipment, and soils to a depth of 3 meters (10 feet) below the tank base. Where necessary, deep soil excavation would also be conducted to remove contamination plumes within the soil column. The adjacent cribs and trenches (ditches) would be covered with an engineered modified RCRA Subtitle C barrier.

Under Tank Closure Alternative 6A, Option Case, tank waste would be retrieved to a volume corresponding to 99.9 percent retrieval; all tank farms would be clean closed by removing the tanks, ancillary equipment, and soils to a depth of 3 meters (10 feet) below the tank base. Where necessary, deep soil excavation would also be conducted to remove contamination plumes within the soil column. In addition, the adjacent cribs and trenches (ditches) would be clean closed.

5.1.1.9.1 Actions and Timeframes Influencing Groundwater Impacts

Summaries of the proposed actions and timelines for Tank Closure Alternative 6A are provided in Chapter 2, Section 2.5. For the long-term groundwater impacts analysis, three major periods were identified for Tank Closure Alternative 6A, as follows:

- The past-practice period was assumed to start with the onset of tank farm operations in 1944 and continue through 2007, when tank and infrastructure upgrades were complete. Releases to the vadose zone occurred during the past-practice period from past leaks at the SST farms and discharges to the cribs and trenches (ditches) associated with the B, BX, BY, T, TX, and TY tank farms. The groundwater impacts during the past-practice period under Tank Closure Alternative 6A presented in this section are common to all of the Tank Closure alternatives.
- The retrieval period was assumed to start in 2008 and end in CY 2250. This period includes waste retrieval, WTP pretreatment and treatment, clean closure of the SST farm system, and 100 years of postclosure care. During this period, 99.9 percent of the waste would be retrieved from the tanks and all tank farms would be clean closed. Under Tank Closure Alternative 6A, Base Case, the adjacent cribs and trenches (ditches) would be covered with an engineered, modified RCRA Subtitle C barrier; under Alternative 6A, Option Case, they would be clean closed. In both cases, the highly contaminated soil would be treated at the Preprocessing Facility (PPF) and the washed soil would be disposed of in the RPPDF.
- The post-administrative control period was assumed to start in CY 2251 and continue through the 10,000-year period of analysis until CY 11,940.

5.1.1.9.2 COPC Drivers

A total of 19 COPCs were analyzed for Tank Closure Alternative 6A. Complete results for all 19 COPCs are tabulated in Appendices M, N, and O, but this discussion of long-term impacts associated with Tank Closure Alternative 6A is focused on the following COPC drivers:

- Radiological risk drivers: tritium, iodine-129, technetium-99, and uranium-238
- Chemical risk drivers: none
- Chemical hazard drivers: chromium, nitrate, and total uranium

The COPC drivers for Tank Closure Alternative 6A were selected by evaluating the risk or hazard associated with all 19 COPCs during the year of peak risk or hazard at the Core Zone Boundary during the 10,000-year period of analysis and selecting the major contributors. This process is described in Appendix Q. Uranium-238 and total uranium were added to the COPC drivers, although their contributions to risk and hazard are not dominant during the year of peak risk or hazard. Tritium was added to the list of COPC drivers because of its contribution to risk during the early part of the period of analysis. The radiological risk drivers account for essentially 100 percent of the radiological risk. The

only predicted chemical risk is from 2,4,6-trichlorophenol, calculated as 1×10^{-11} , which is negligible for purposes of this discussion. The chemical hazard drivers account for 100 percent of the chemical hazard associated with Tank Closure Alternative 6A.

The COPC drivers that are discussed in detail in this section fall into three categories. Iodine-129, technetium-99, chromium, and nitrate are all mobile (i.e., move with groundwater) and long lived (relative to the 10,000-year period of analysis), or stable. They are essentially conservative tracers. Tritium is also mobile, but short lived. The half-life of tritium is about 13 years, and tritium concentrations are strongly attenuated by radioactive decay during travel through the vadose zone and groundwater systems. Finally, uranium-238 and total uranium are long lived, or stable, but are not as mobile as the other COPC drivers. These constituents move about seven times more slowly than groundwater. As the analyses of release, concentration versus time, and spatial distribution of the COPC drivers are presented, the distinct behavior of these three groups will become apparent.

The other COPCs that were analyzed do not significantly contribute to drinking water risk at the Core Zone Boundary during the period of analysis because of limited inventories, high retardation factors (i.e., retention in the vadose zone), short half-lives (i.e., rapid radioactive decay), or a combination of these factors.

5.1.1.9.3 Analysis of Release and Mass Balance

This section presents the impacts of Tank Closure Alternative 6A (Base and Option Cases) in terms of the total amount of COPCs released to the vadose zone, groundwater, and the Columbia River during the 10,000-year period of analysis. Releases of radionuclides are totaled in curies; chemicals, in kilograms (see Figures 5–195 through 5–206). Three subtotals are plotted, representing releases from cribs and trenches (ditches), past leaks, and other tank farm sources (e.g., tank residuals, ancillary equipment). Note that the release amounts are plotted on a logarithmic scale to facilitate visual comparison of releases that vary over four orders of magnitude within the same series of figures.

Figure 5–195 shows the estimated release to the vadose zone of the radiological risk drivers under the Base Case, which would include use of a modified RCRA Subtitle C barrier, and Figure 5–196, the chemical hazard drivers. The predominant sources of tritium, chromium, and nitrate are the cribs and trenches (ditches) associated with the B, BX, BY, T, TX, and TY tank farms. For all other COPC drivers, the predominant sources are past leaks. This suggests that past leaks, which were released during the past-practice period, as well as the cribs and trenches (ditches), are both important impact drivers under Tank Closure Alternative 6A, Base Case.

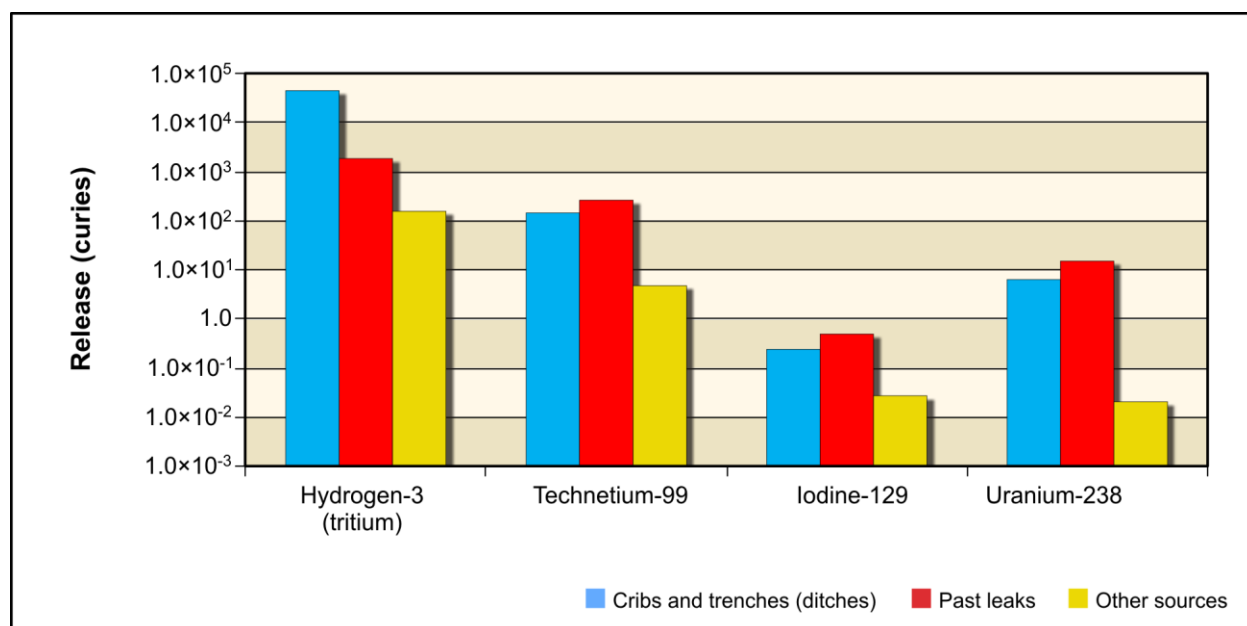


Figure 5–195. Tank Closure Alternative 6A, Base Case, Releases of Radioactive Constituent of Potential Concern Drivers to Vadose Zone for Entire 10,000-Year Analysis Period

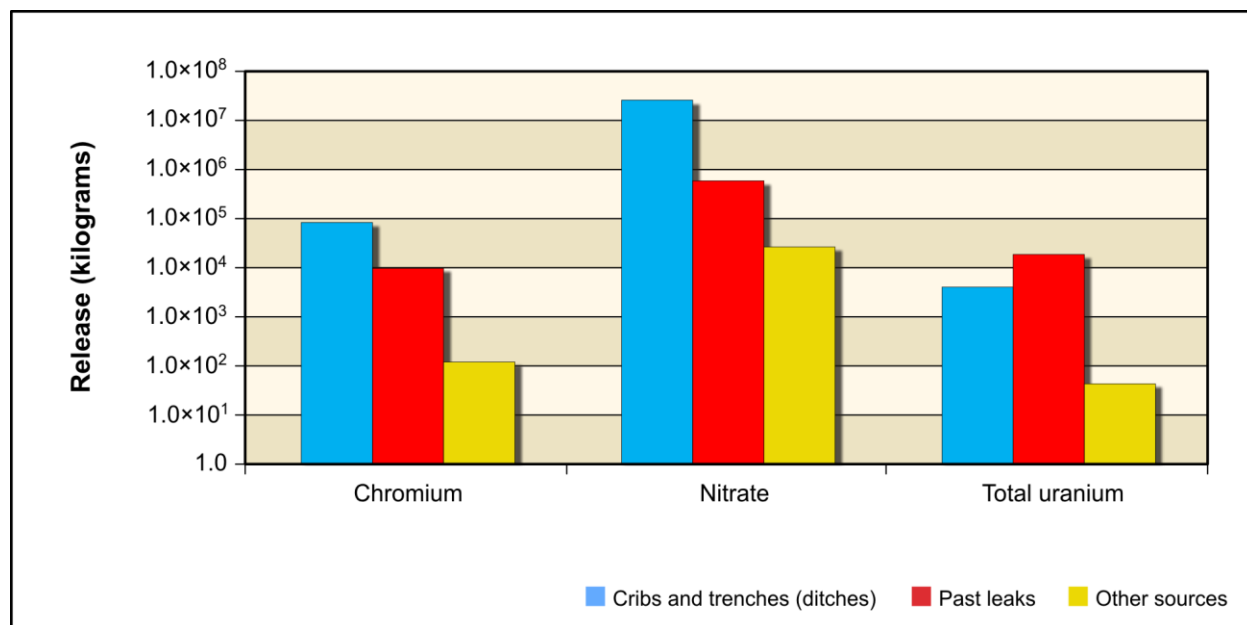


Figure 5–196. Tank Closure Alternative 6A, Base Case, Releases of Chemical Constituent of Potential Concern Drivers to Vadose Zone for Entire 10,000-Year Analysis Period

Figure 5–197 shows the estimated release to the vadose zone of the radiological risk drivers under the Option Case, which would include clean closure of cribs and trenches (ditches), and Figure 5–198, the chemical hazard drivers. The predominant sources of tritium, the conservative tracers (iodine-129, technetium-99, chromium, and nitrate), uranium-238, and total uranium are similar to those in the vadose zone under the Base Case.

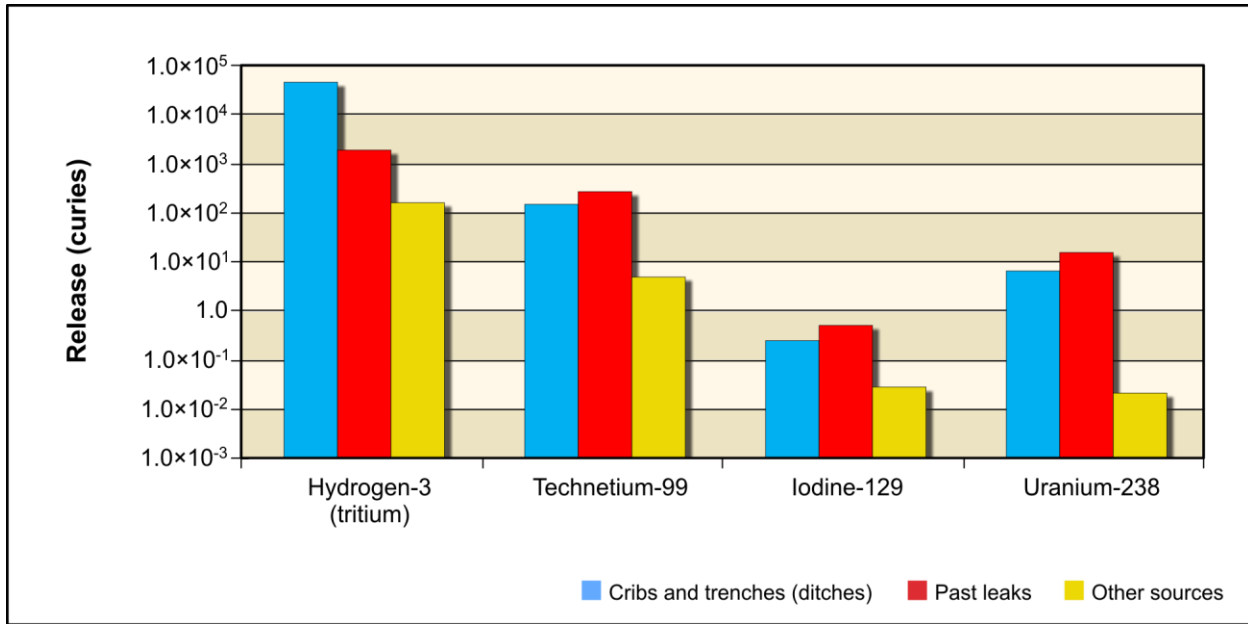


Figure 5–197. Tank Closure Alternative 6A, Option Case, Releases of Radioactive Constituent of Potential Concern Drivers to Vadose Zone for Entire 10,000-Year Analysis Period

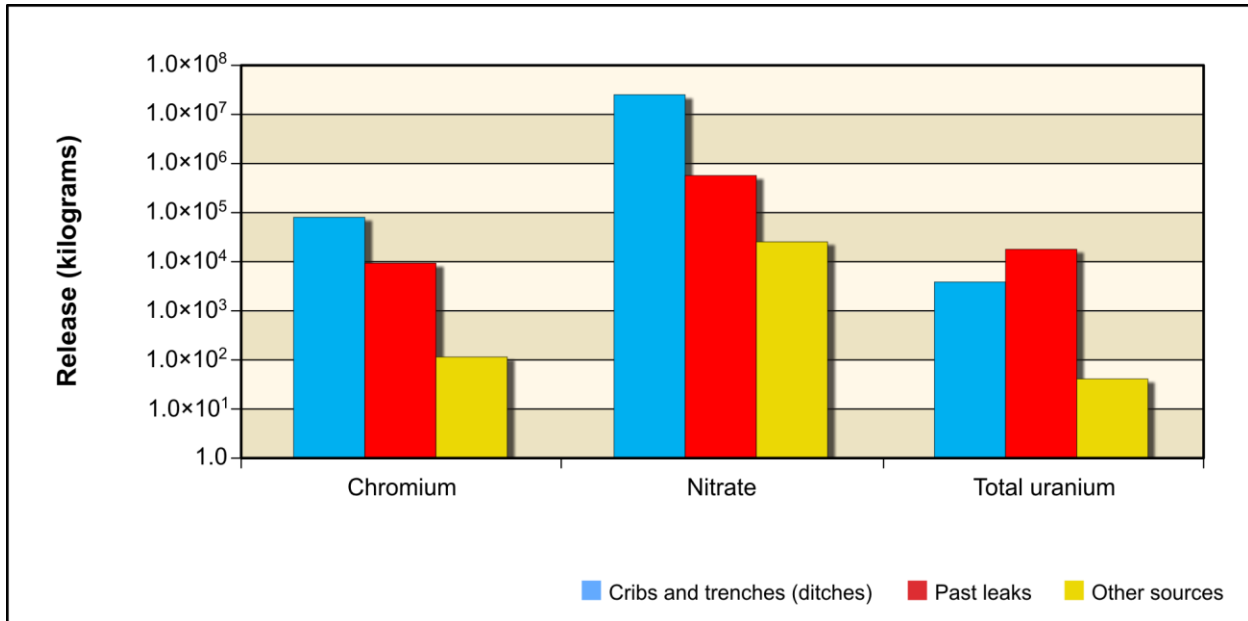


Figure 5–198. Tank Closure Alternative 6A, Option Case, Releases of Chemical Constituent of Potential Concern Drivers to Vadose Zone for Entire 10,000-Year Analysis Period

Figure 5–199 shows the estimated release to groundwater of the radiological risk drivers under the Base Case and Figure 5–200, the chemical hazard drivers. In addition to the total inventory released, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. For the conservative tracers (iodine-129, technetium-99, chromium, and nitrate), the amount released to groundwater is essentially equal to the amount released to the vadose zone for cribs and trenches (ditches) and past leaks. For other tank farm sources, only about 40 percent, at most, is released to groundwater.

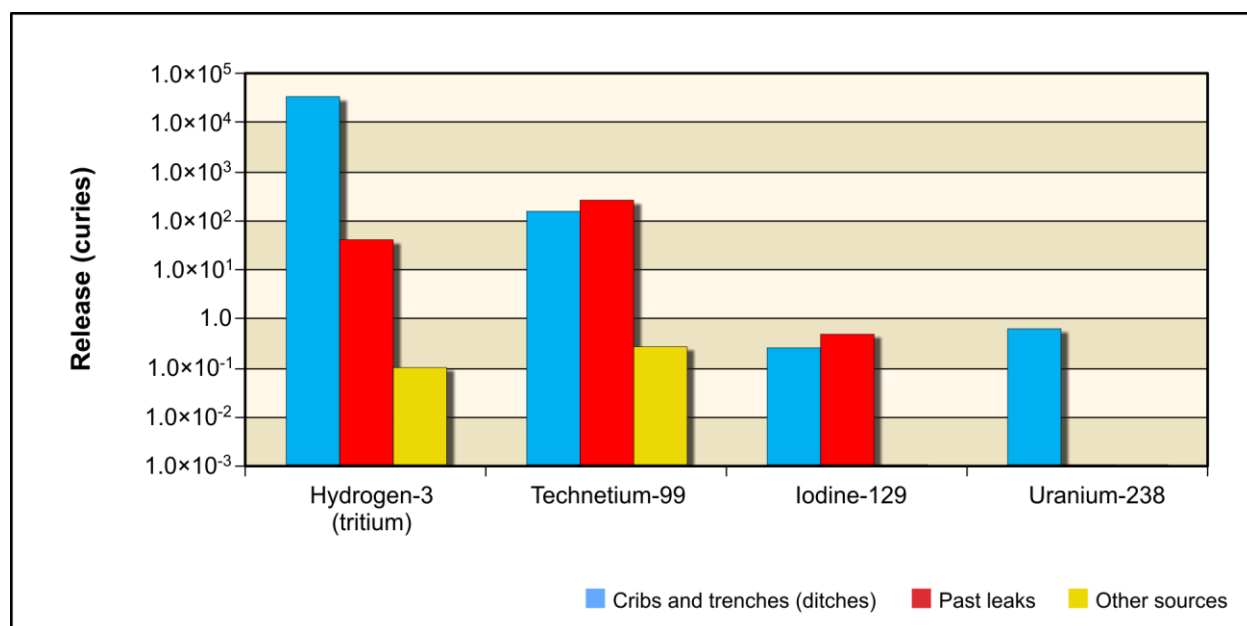


Figure 5–199. Tank Closure Alternative 6A, Base Case, Releases of Radioactive Constituent of Potential Concern Drivers to Groundwater for Entire 10,000-Year Analysis Period

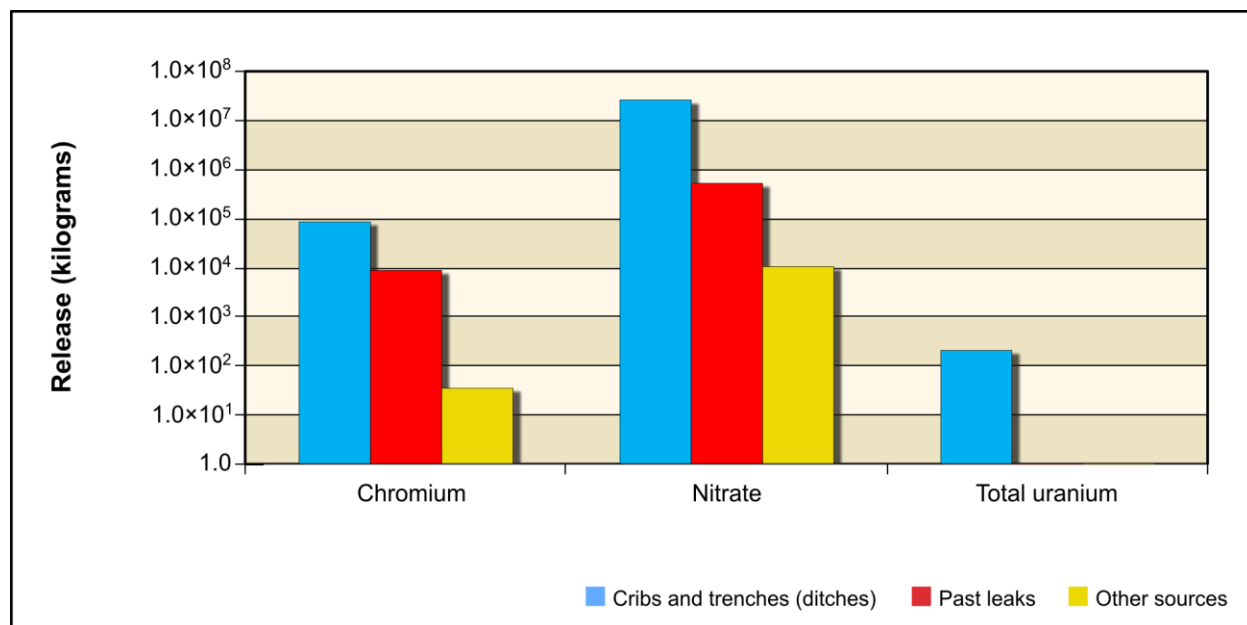


Figure 5–200. Tank Closure Alternative 6A, Base Case, Releases of Chemical Constituent of Potential Concern Drivers to Groundwater for Entire 10,000-Year Analysis Period

For uranium-238 and total uranium under the Base Case, the amount released to groundwater is less than that released to the vadose zone because of retardation. The amount of attenuation depends on the rate of moisture movement through the vadose zone. For releases from cribs and trenches (ditches), where moisture movement through the vadose zone is relatively rapid (because of the volume of water associated with the source), about 10 percent of the uranium-238 and 5 percent of the total uranium reach groundwater during the period of analysis; for past leaks and other sources, essentially none of the total inventory reaches groundwater during the period of analysis.

For tritium under the Base Case, the amount released to groundwater is attenuated by radioactive decay. For cribs and trenches (ditches), about 71 percent of the total inventory reaches groundwater in the analysis; for past leaks, only 2 percent reaches groundwater; and for other sources, less than one-tenth of 1 percent reaches groundwater. These results suggest that tritium impacts on groundwater are dominated by releases from cribs and trenches (ditches) and that radioactive decay of tritium is an important attenuation process. They also suggest that uranium-238 and total uranium impacts on groundwater would occur later in the post-administrative control period because of the long travel times in the vadose zone for these COPCs.

Figure 5-201 shows the estimated release to groundwater of the radiological risk drivers under the Option Case and Figure 5-202, the chemical hazard drivers. In addition to the total inventory released, release to groundwater is controlled by the transport properties of the COPC drivers and by the rate of moisture movement through the vadose zone. For the conservative tracers (iodine-129, technetium-99, chromium, and nitrate), the amount released to groundwater is about 13 to 30 percent less than the amount released to the vadose zone.

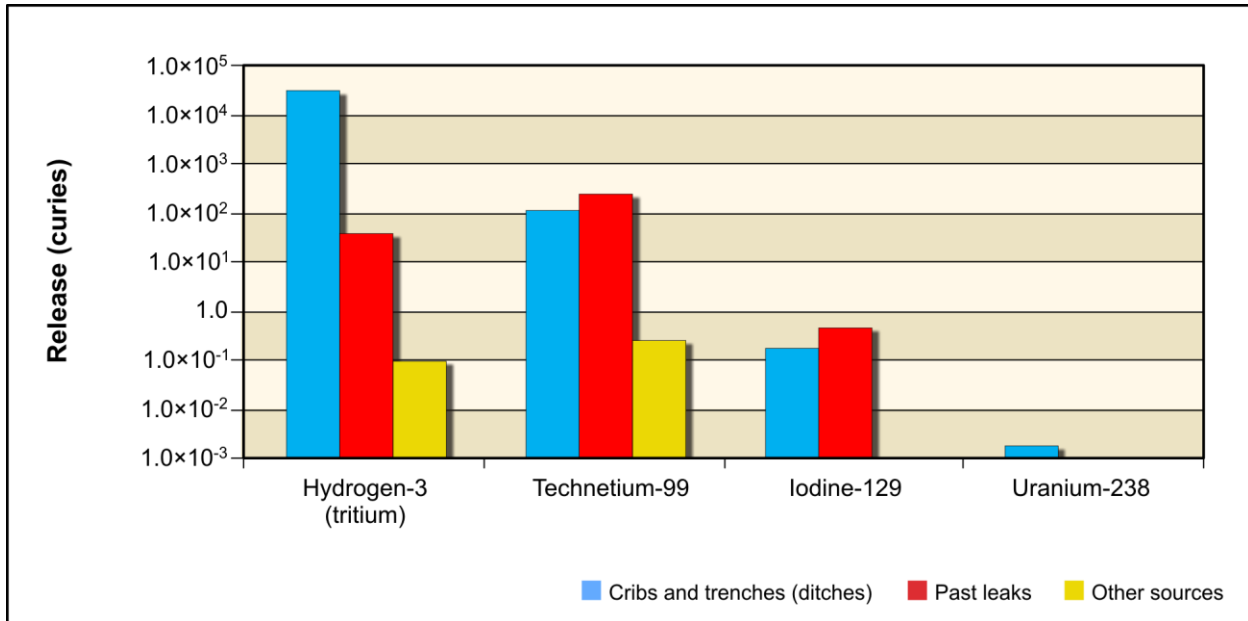


Figure 5-201. Tank Closure Alternative 6A, Option Case, Releases of Radioactive Constituent of Potential Concern Drivers to Groundwater for Entire 10,000-Year Analysis Period

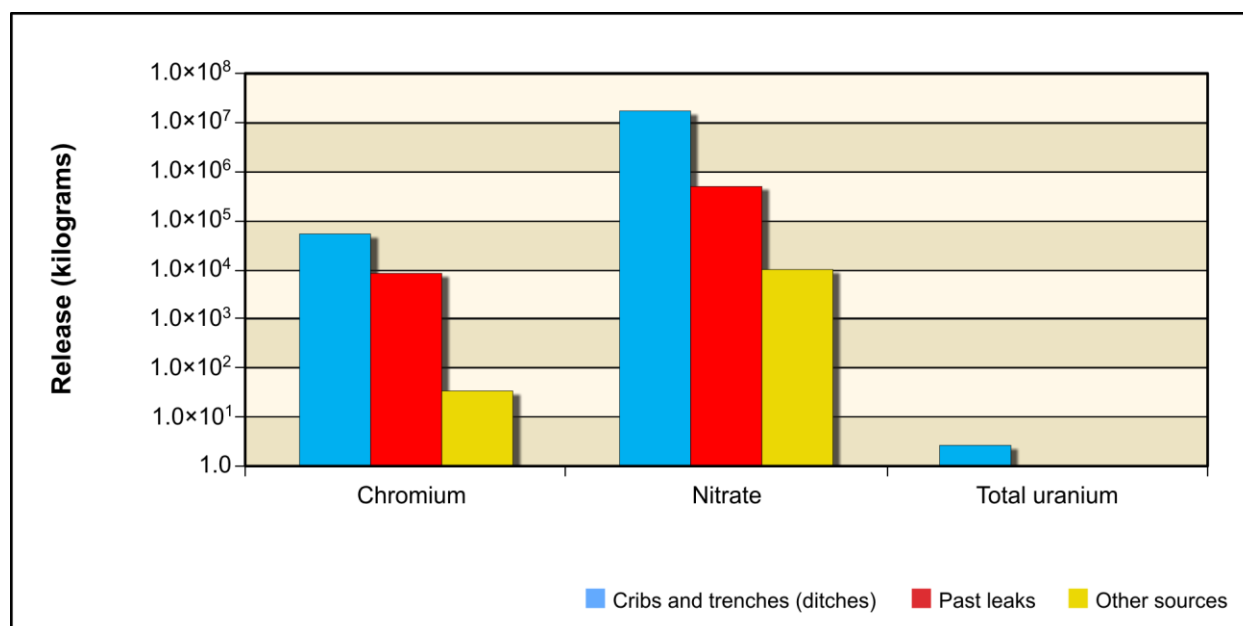


Figure 5–202. Tank Closure Alternative 6A, Option Case, Releases of Chemical Constituent of Potential Concern Drivers to Groundwater for Entire 10,000-Year Analysis Period

For uranium-238 and total uranium under the Option Case, the amount released to groundwater is less than that released to the vadose zone because of vadose zone retention. The amount of this retention depends on the type of contaminant source, specifically volume and timing of moisture movement through the vadose zone. For releases from cribs and trenches (ditches), where moisture movement through the vadose zone is relatively rapid (because of the volume of water associated with the source), less than one-tenth of 1 percent of the total inventory reaches groundwater during the period of analysis. For past leaks and other tank farm sources, essentially none of the total inventory reaches groundwater during the period of analysis.

For tritium under the Option Case, the amount released to groundwater is attenuated by radioactive decay. For cribs and trenches (ditches), about 71 percent of the total inventory reaches groundwater in the analysis; for past leaks, only 2 percent reaches groundwater; and for other sources, essentially no tritium reaches groundwater. These results suggest that tritium impacts on groundwater are dominated by releases from cribs and trenches (ditches) and that radioactive decay of tritium is an important attenuation process. They also suggest that uranium-238 and total uranium impacts on groundwater would decrease over time because the long travel times in the vadose zone for these COPCs allow much of what was released to be collected and treated when the cribs and trenches (ditches) are removed and their deep plumes remediated.

Figure 5–203 shows the estimated release to the Columbia River of the radiological risk drivers under the Base Case and Figure 5–204, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. For the conservative tracers (iodine-129, technetium-99, chromium, and nitrate), the amount released to the Columbia River is essentially equal to the amount released to groundwater.

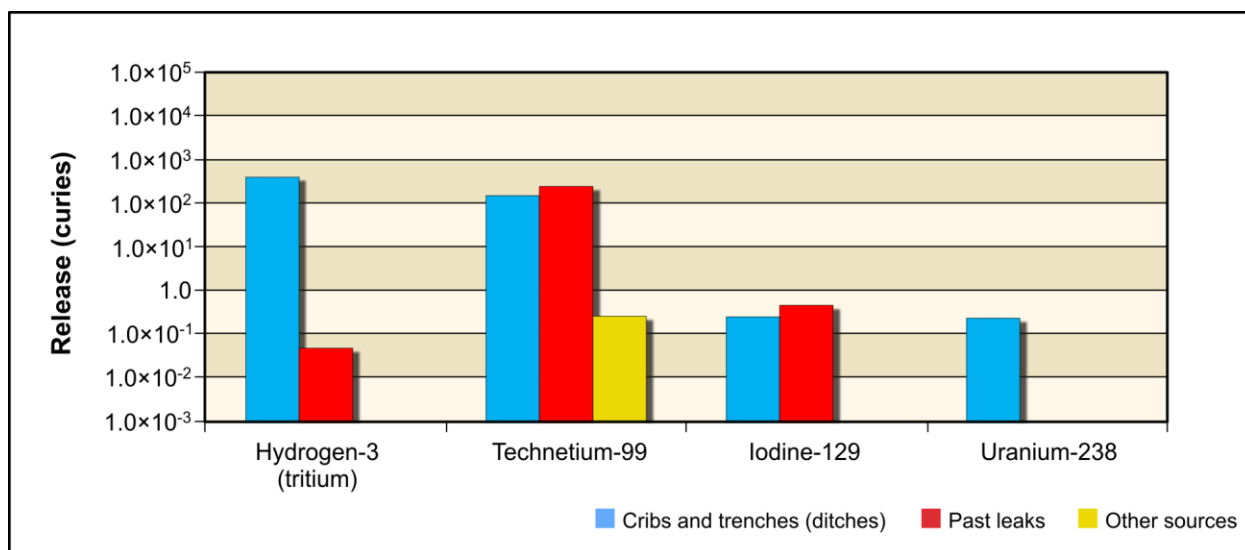


Figure 5–203. Tank Closure Alternative 6A, Base Case, Releases of Radioactive Constituent of Potential Concern Drivers to Columbia River for Entire 10,000-Year Analysis Period

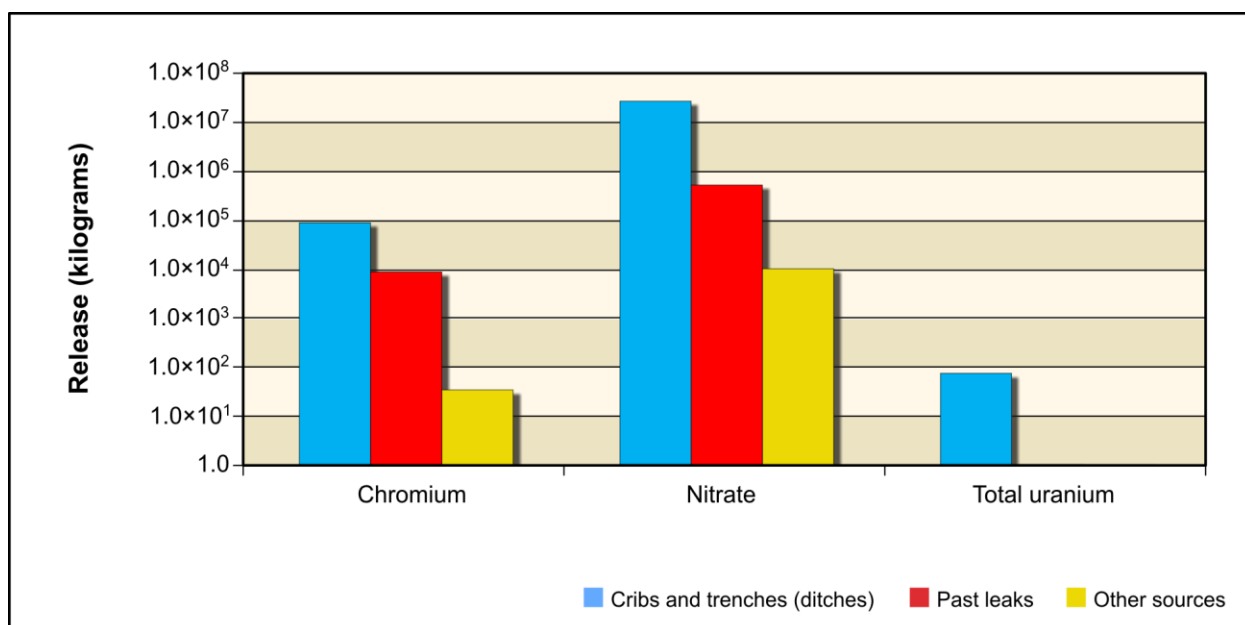


Figure 5–204. Tank Closure Alternative 6A, Base Case, Releases of Chemical Constituent of Potential Concern Drivers to Columbia River for Entire 10,000-Year Analysis Period

For uranium-238 and total uranium under the Base Case, the amount released to the Columbia River is less than that released to groundwater because of retardation. For cribs and trenches (ditches), less than 40 percent of the amount released to groundwater during the period of analysis reaches the Columbia River.

For tritium under the Base Case, the amount released to the Columbia River is attenuated by radioactive decay. For cribs and trenches (ditches), only about 1 percent of the tritium released to groundwater reaches the Columbia River. For past leaks and other sources, less than 1 percent of the tritium released to groundwater reaches the Columbia River. These results suggest that tritium impacts on the Columbia River are strongly attenuated by radioactive decay. They also suggest that uranium-238 and total uranium

impacts on the Columbia River would occur later in the post-administrative control period because of the long travel times in the vadose zone and through the groundwater system for these COPCs.

Figure 5–205 shows the estimated release to the Columbia River of the radiological risk drivers under the Option Case and Figure 5–206, the chemical hazard drivers. Release to the Columbia River is controlled by the transport properties of the COPC drivers. For the conservative tracers (iodine-129, technetium-99, chromium, and nitrate), the amount released to the Columbia River is essentially equal to the amount released to groundwater. For uranium-238 and total uranium, the amount released to the Columbia River from groundwater is effectively zero, as essentially no uranium reaches groundwater from the vadose zone in the analysis. For tritium, the amount released to the Columbia River is attenuated by radioactive decay. For cribs and trenches (ditches), only about 1 percent of the tritium released to groundwater reaches the Columbia River in the analysis. For past leaks and other sources, less than 1 percent of the tritium released to groundwater reaches the Columbia River in the analysis. These results suggest that tritium impacts on the Columbia River are strongly attenuated by radioactive decay. They also suggest that uranium-238 and total uranium would not impact the Columbia River, as much of what was released would be collected when the cribs and trenches (ditches) are removed and their deep plumes remediated.

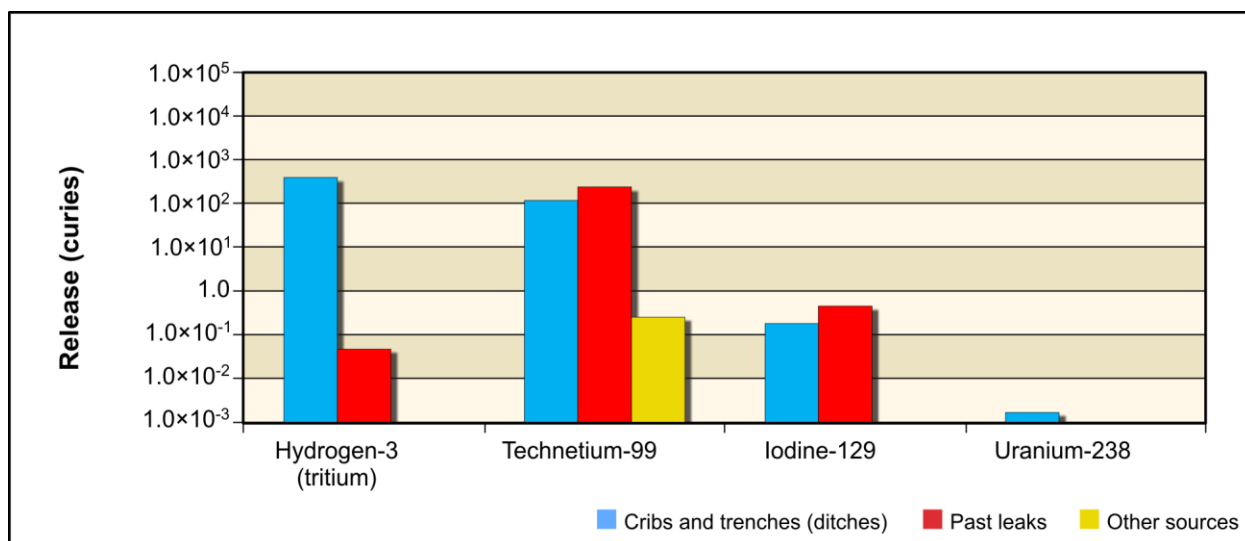


Figure 5–205. Tank Closure Alternative 6A, Option Case, Releases of Radioactive Constituent of Potential Concern Drivers to Columbia River for Entire 10,000-Year Analysis Period

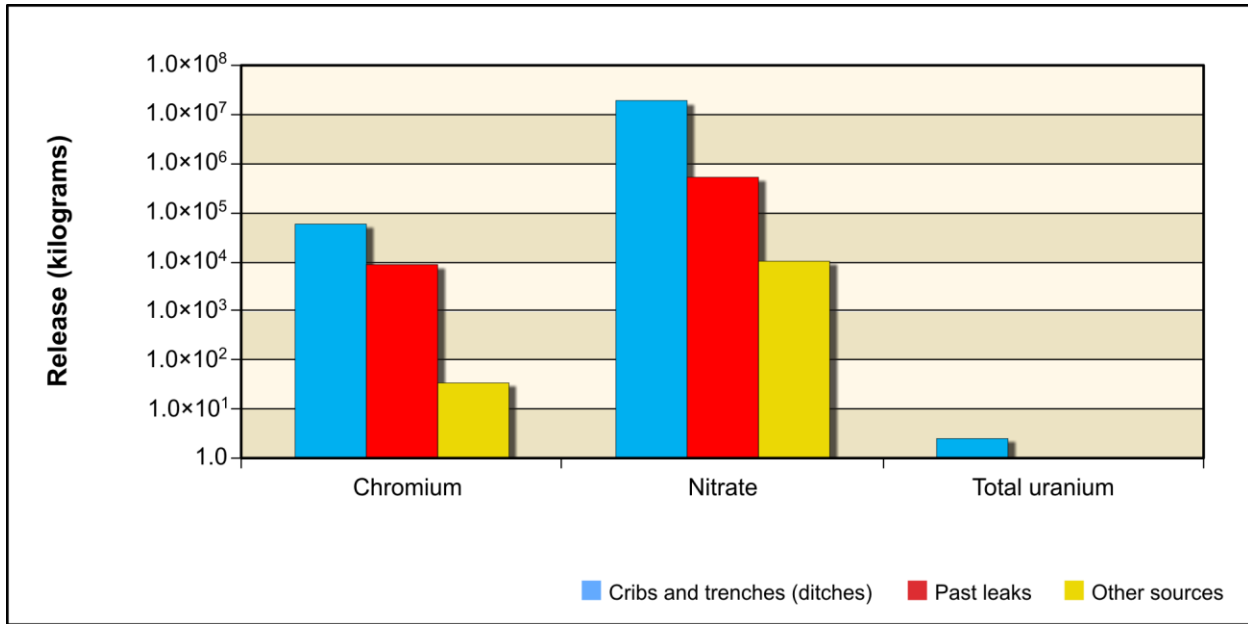


Figure 5–206. Tank Closure Alternative 6A, Option Case, Releases of Chemical Constituent of Potential Concern Drivers to Columbia River for Entire 10,000-Year Analysis Period

5.1.1.9.4 Analysis of Concentration Versus Time

This section presents the analysis of Tank Closure Alternative 6A impacts in terms of groundwater concentration versus time at the Core Zone Boundary and the Columbia River nearshore. Concentrations of radionuclides are in picocuries per liter; chemicals, in micrograms per liter (see Tables 5–12 and 5–13 and Figures 5–207 through 5–220). The benchmark concentration of each radionuclide and chemical is also shown. Note that the concentrations are plotted on a logarithmic scale to facilitate visual comparison of concentrations that vary over five orders of magnitude. Tables 5–12 and 5–13 list the maximum concentrations under the Base and Option Cases for the COPCs in the peak year after CY 2050 at the tank farm barriers, Core Zone Boundary, and Columbia River nearshore. Under Tank Closure Alternative 6A, Base Case, tritium, uranium-238, and total uranium never exceed their benchmark concentrations at any location beyond CY 2050. The highest impact areas are the B, S, and T Barriers and the Core Zone Boundary, where concentrations of technetium-99, iodine-129, chromium, and nitrate peak above their benchmark concentration values. At the Columbia River nearshore, iodine-129 approaches, but does not peak above the benchmark concentration after CY 2050. The maximum concentrations at the tank farm barriers, Core Zone Boundary, and Columbia River nearshore under the Option Case are similar to those under the Base Case.

Figure 5–207 shows the concentration versus time for tritium under the Base Case. Releases from cribs and trenches (ditches) cause the groundwater concentrations at the Core Zone Boundary to exceed the benchmark concentrations by one to two orders of magnitude for a short period of time during the early part of the period of analysis. This time period is represented by the first series of sharp inflections in the curve for the Core Zone Boundary from approximately CY 1955 until CY 1980. During the same period of time, the Columbia River nearshore concentrations approach but never reach the benchmark concentration. Because the half-life of tritium is less than 13 years, radioactive decay rapidly attenuates groundwater concentration.

The concentration versus time for tritium under the Option Case is essentially identical to that under the Base Case (see Figure 5–208).

Table 5–12. Tank Closure Alternative 6A, Base Case, Maximum COPC Concentrations in the Peak Year at the Tank Farm Barriers, Core Zone Boundary, and Columbia River Nearshore

Contaminant	A Barrier	B Barrier	S Barrier	T Barrier	U Barrier	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide (picocuries per liter)								
Hydrogen-3 (tritium)	7 (2050)	572 (2052)	31 (2050)	2,870 (2050)	14 (2050)	628 (2051)	477 (2051)	20,000
Technetium-99	963 (2103)	3,480 (2056)	1,480 (2052)	6,530 (2050)	138 (2067)	3,480 (2056)	382 (2251)	900
Iodine-129	1.9 (2100)	4.8 (2092)	2.9 (2050)	12.6 (2050)	0.2 (2071)	4.8 (2092)	0.7 (2265)	1
Chemical (micrograms per liter)								
Chromium	83 (2168)	214 (2050)	156 (2050)	354 (2045)	6 (2050)	214 (2050)	71 (2076)	100
Nitrate	16,800 (2172)	171,000 (2055)	4,630 (2051)	62,000 (2053)	413 (2050)	171,000 (2055)	17,200 (2122)	45,000

Note: Corresponding calendar years shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.

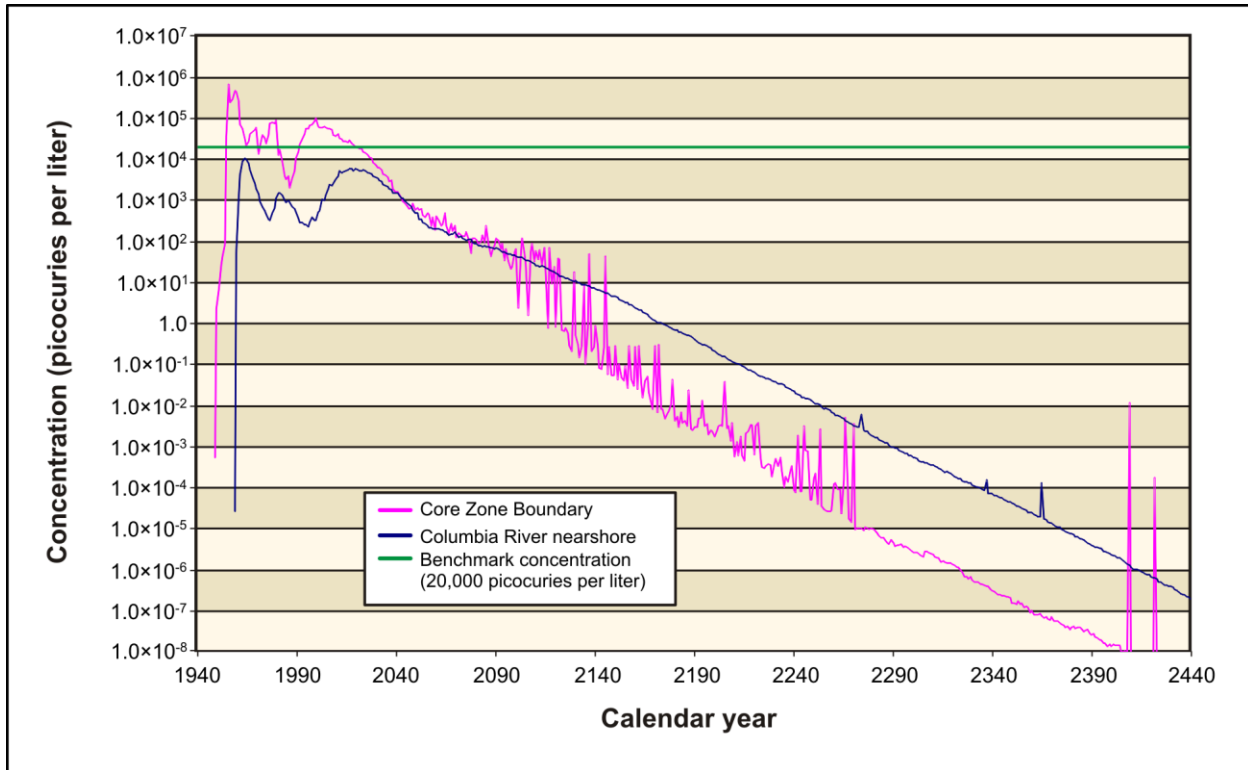
Key: COPC=constituent of potential concern.

Table 5–13. Tank Closure Alternative 6A, Option Case, Maximum COPC Concentrations in the Peak Year at the Tank Farm Barriers, Core Zone Boundary, and Columbia River Nearshore

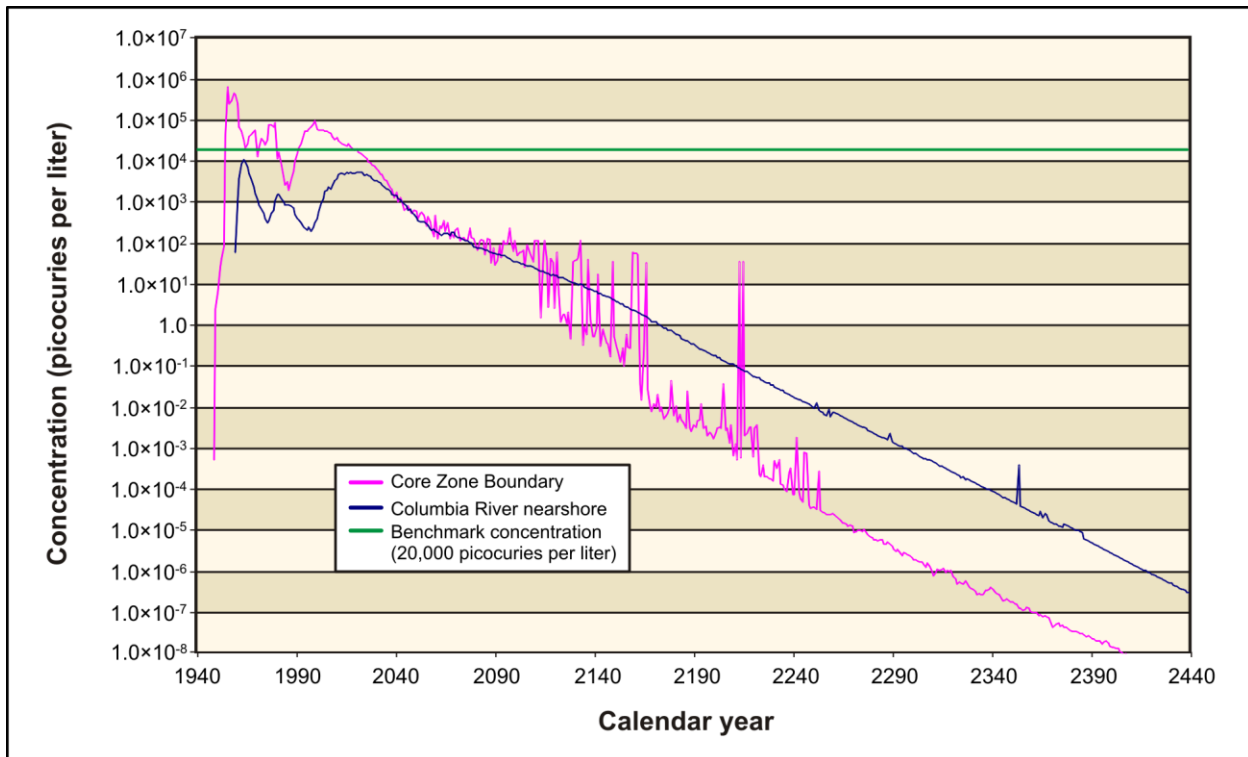
Contaminant	A Barrier	B Barrier	S Barrier	T Barrier	U Barrier	Core Zone Boundary	Columbia River Nearshore	Benchmark Concentration
Radionuclide (picocuries per liter)								
Hydrogen-3 (tritium)	8 (2050)	455 (2057)	31 (2050)	2,390 (2043)	14 (2050)	660 (2050)	501 (2050)	20,000
Technetium-99	963 (2103)	3,650 (2066)	1,480 (2052)	6,530 (2050)	138 (2067)	3,650 (2066)	396 (2239)	900
Iodine-129	1.9 (2100)	4.8 (2092)	2.9 (2050)	12.6 (2050)	0.2 (2071)	4.8 (2092)	0.8 (2265)	1
Chemical (micrograms per liter)								
Chromium	80 (2164)	208 (2050)	156 (2050)	339 (2050)	6 (2050)	208 (2050)	64 (2076)	100
Nitrate	17,400 (2164)	188,000 (2051)	4,630 (2051)	63,000 (2050)	413 (2050)	188,000 (2051)	17,400 (2146)	45,000

Note: Corresponding calendar years shown in parentheses. Concentrations that would exceed the benchmark value are indicated in **bold** text.

Key: COPC=constituent of potential concern.



**Figure 5-207. Tank Closure Alternative 6A, Base Case, Hydrogen-3 (Tritium)
Concentration Versus Time**



**Figure 5-208. Tank Closure Alternative 6A, Option Case, Hydrogen-3 (Tritium)
Concentration Versus Time**

Figures 5–209 through 5–212 show concentration versus time for iodine-129, technetium-99, chromium, and nitrate (the conservative tracers) under the Base Case. All of the conservative tracers show similar patterns. Releases from cribs and trenches (ditches) cause groundwater concentrations at the Core Zone Boundary to exceed benchmark concentrations by one to two orders of magnitude during the early part of the period of analysis, around CY 1956. The concentrations at the Columbia River nearshore approach the benchmark for a brief time during the early period of analysis but decrease to about two to three orders of magnitude below the benchmark by the end of the period of analysis.

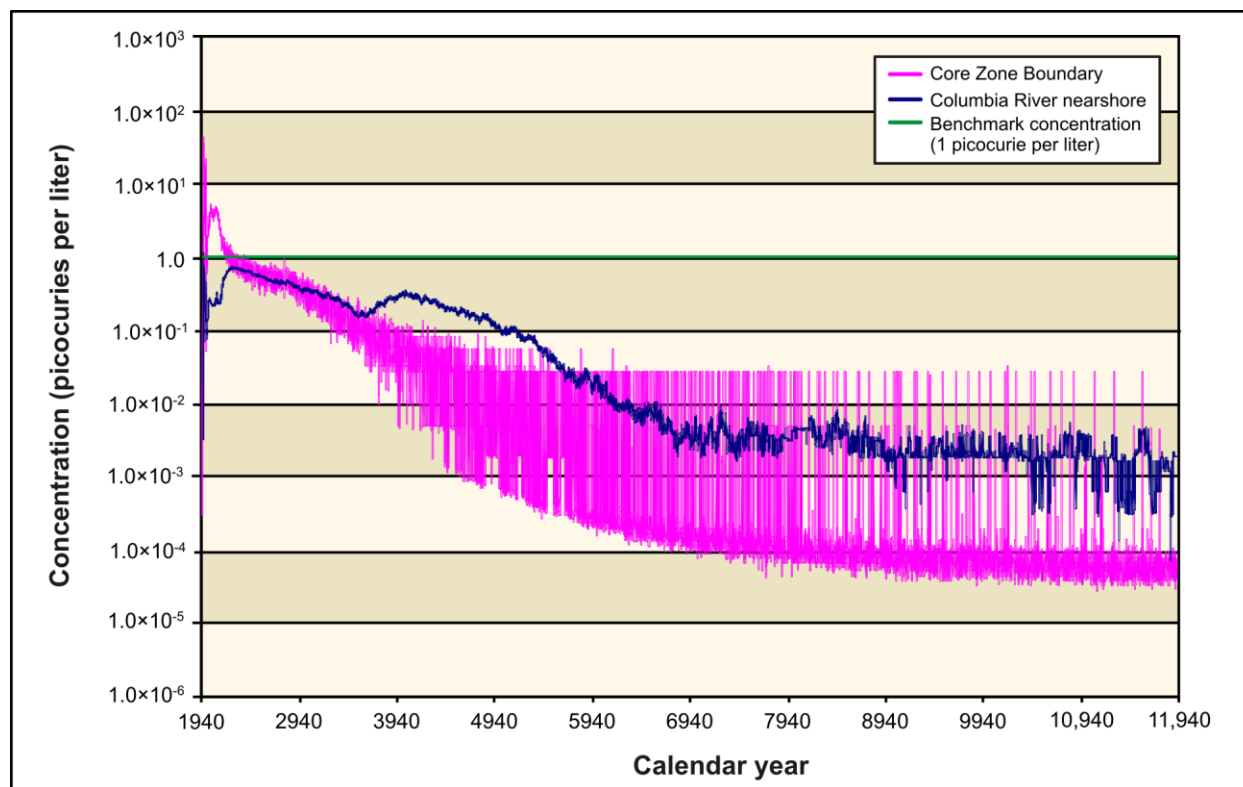
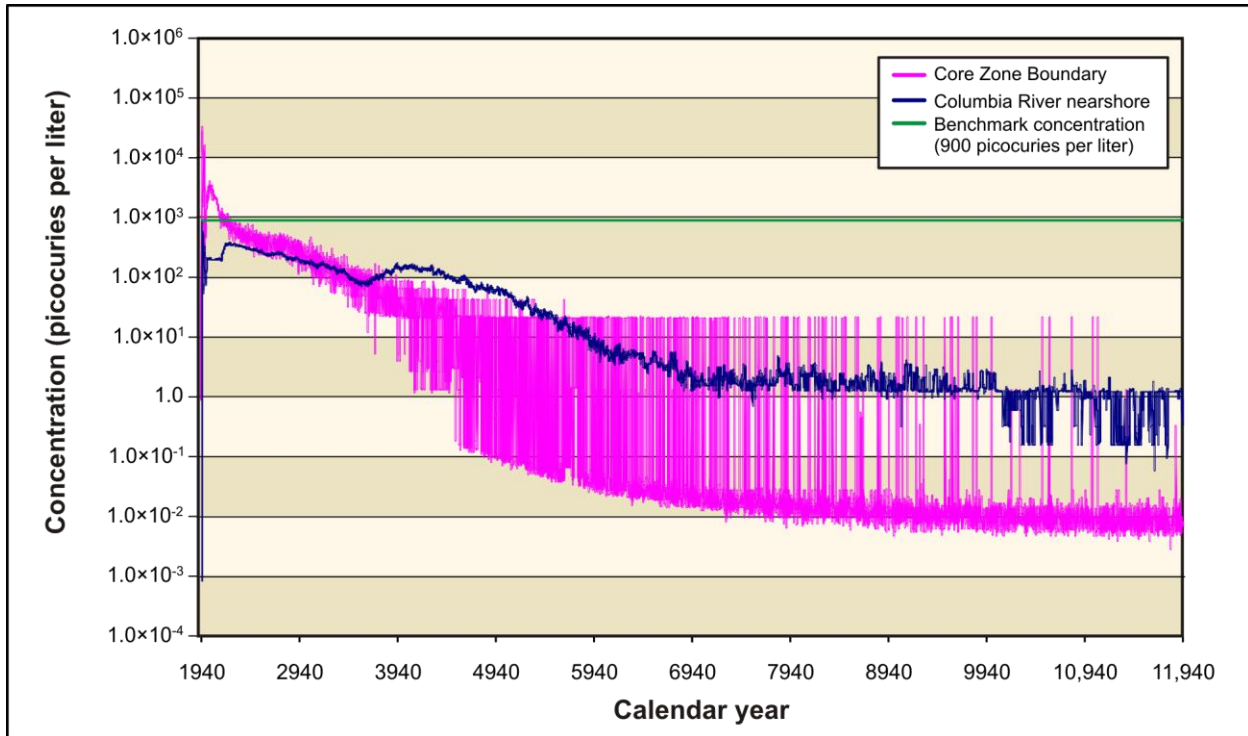
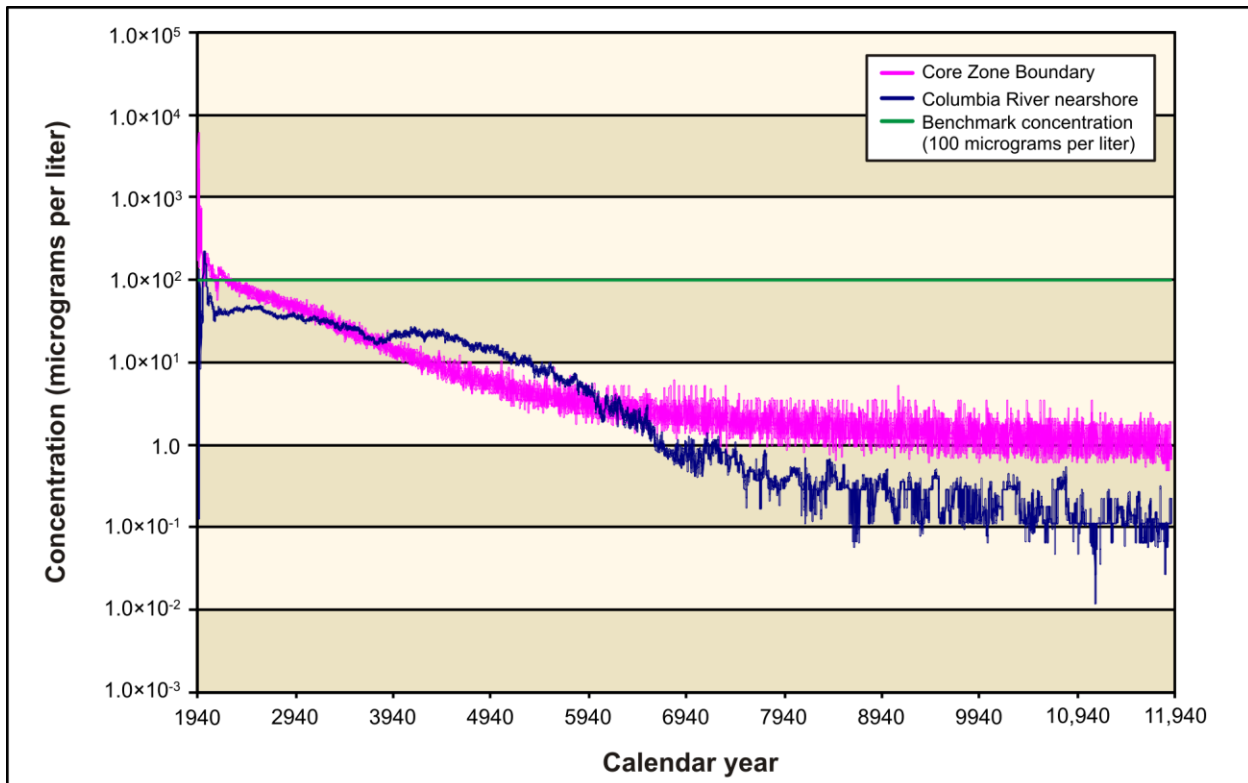


Figure 5–209. Tank Closure Alternative 6A, Base Case, Iodine-129 Concentration Versus Time



**Figure 5-210. Tank Closure Alternative 6A, Base Case, Technetium-99
Concentration Versus Time**



**Figure 5-211. Tank Closure Alternative 6A, Base Case, Chromium
Concentration Versus Time**

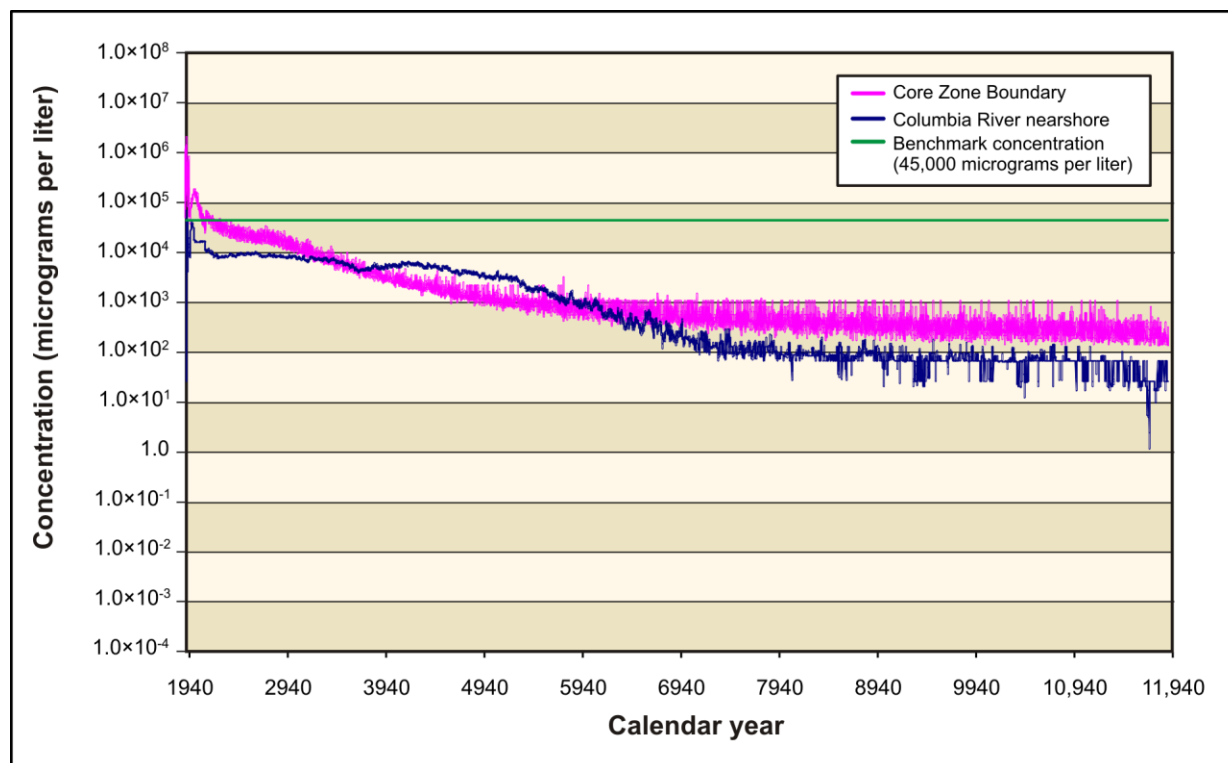
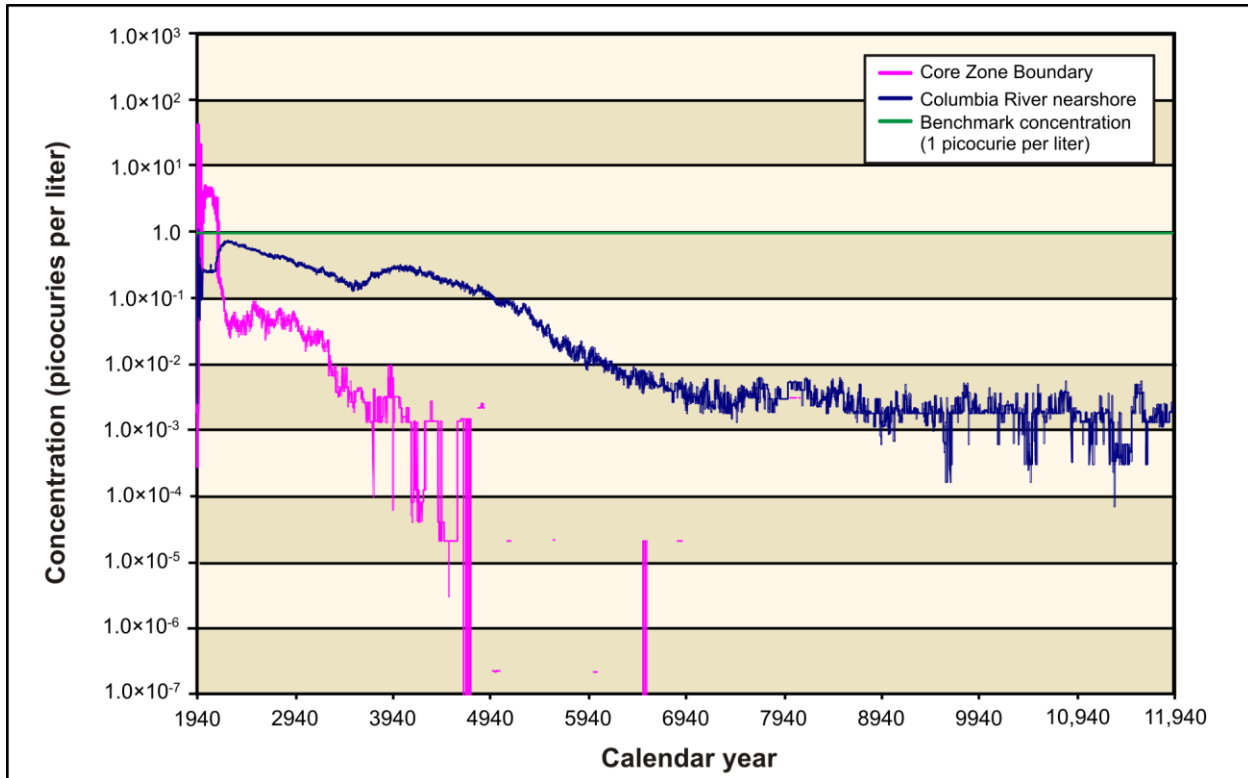
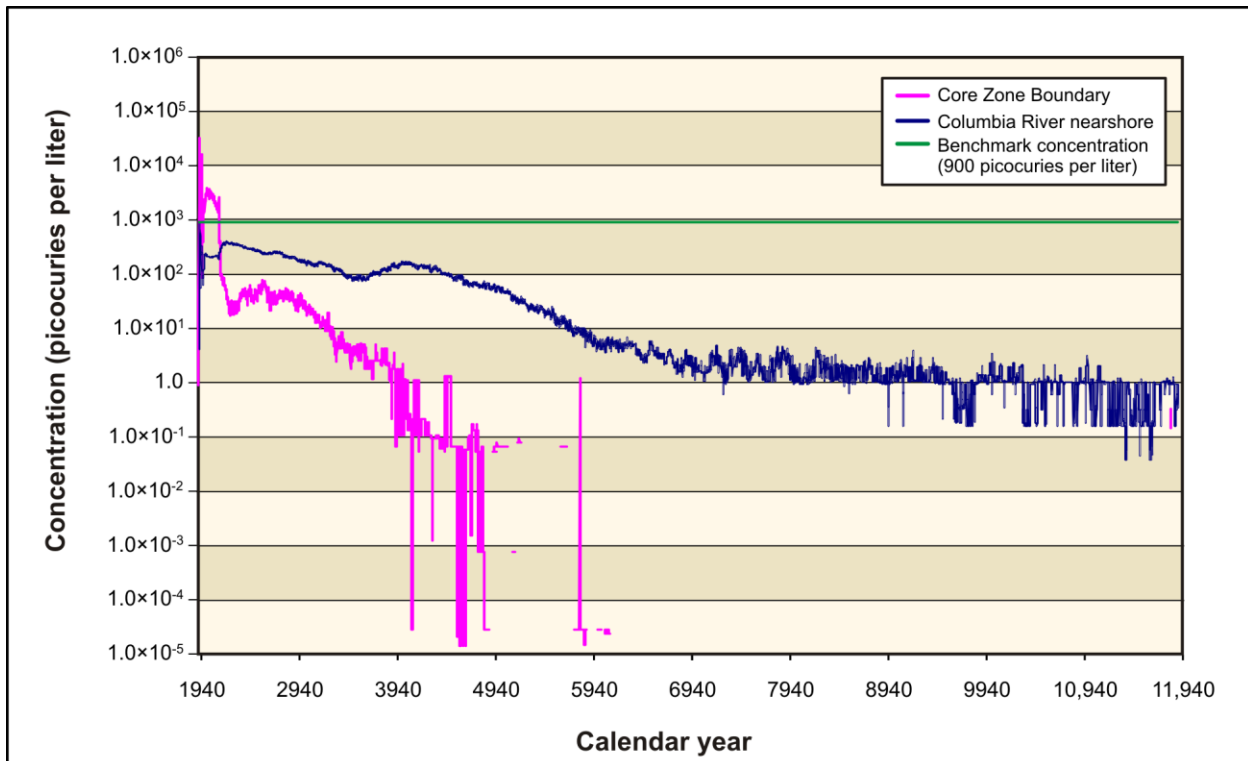


Figure 5-212. Tank Closure Alternative 6A, Base Case, Nitrate Concentration Versus Time

The concentrations of iodine-129, technetium-99, chromium, and nitrate (the conservative tracers) versus time under the Option Case are essentially identical to those under the Base Case during the early part of the period of analysis. Differences arise around CY 3000 when, as a result of clean closure of the cribs and trenches (ditches), the concentrations at the Core Zone Boundary begin to decrease at a much faster rate than under the Base Case. Concentrations range over seven orders of magnitude below the benchmark by the end of the period of analysis (see Figures 5-213 through 5-216).



**Figure 5-213. Tank Closure Alternative 6A, Option Case, Iodine-129
Concentration Versus Time**



**Figure 5-214. Tank Closure Alternative 6A, Option Case, Technetium-99
Concentration Versus Time**

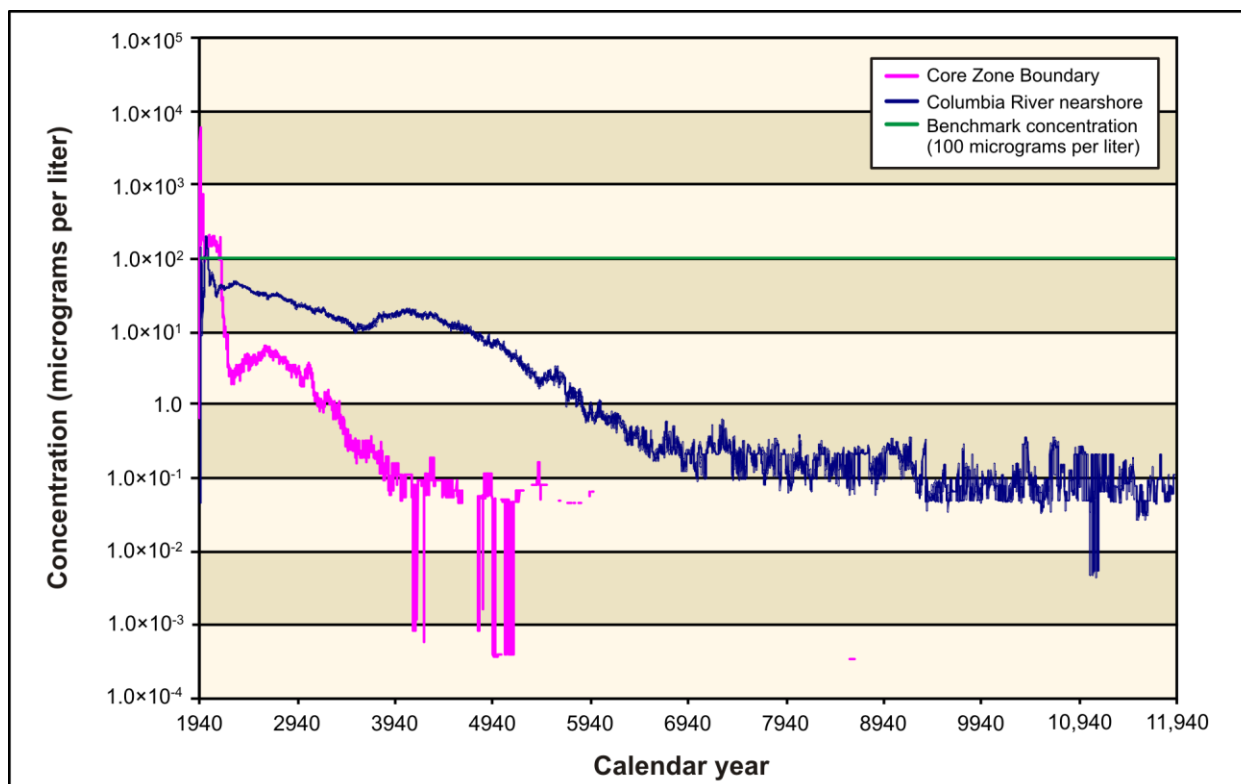


Figure 5-215. Tank Closure Alternative 6A, Option Case, Chromium Concentration Versus Time

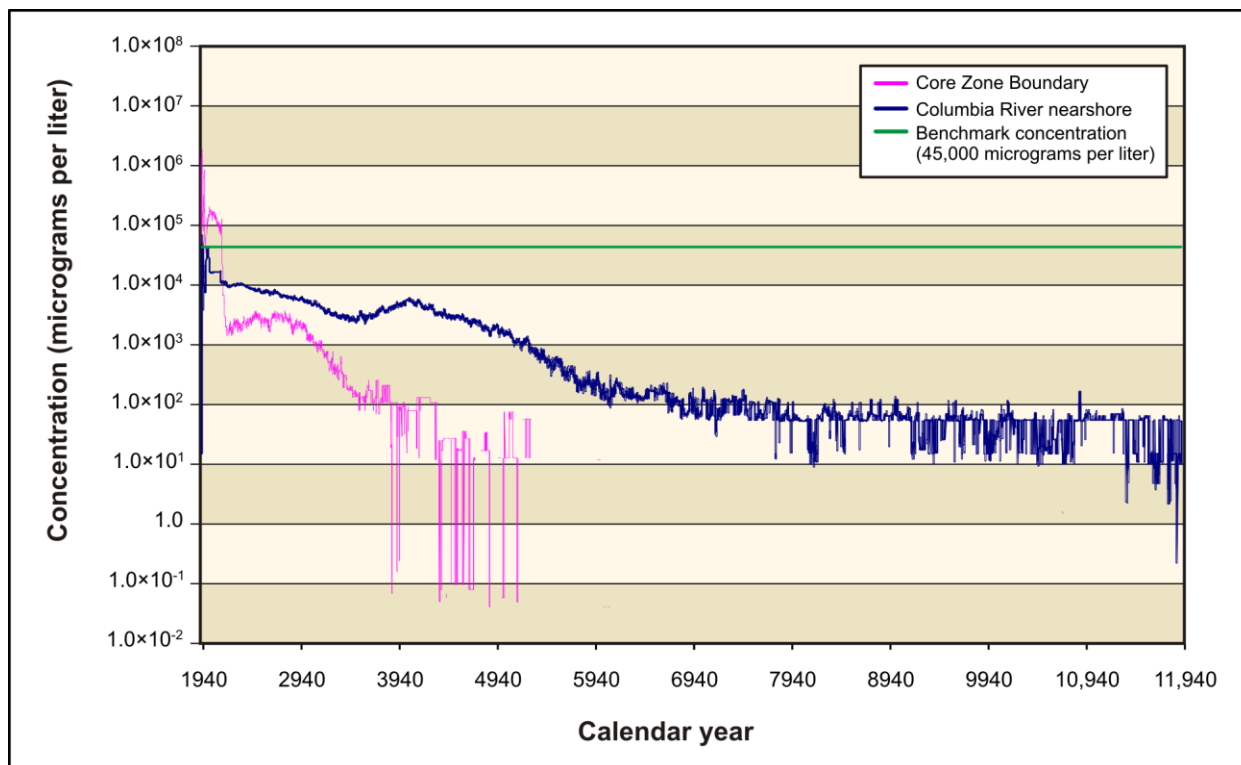
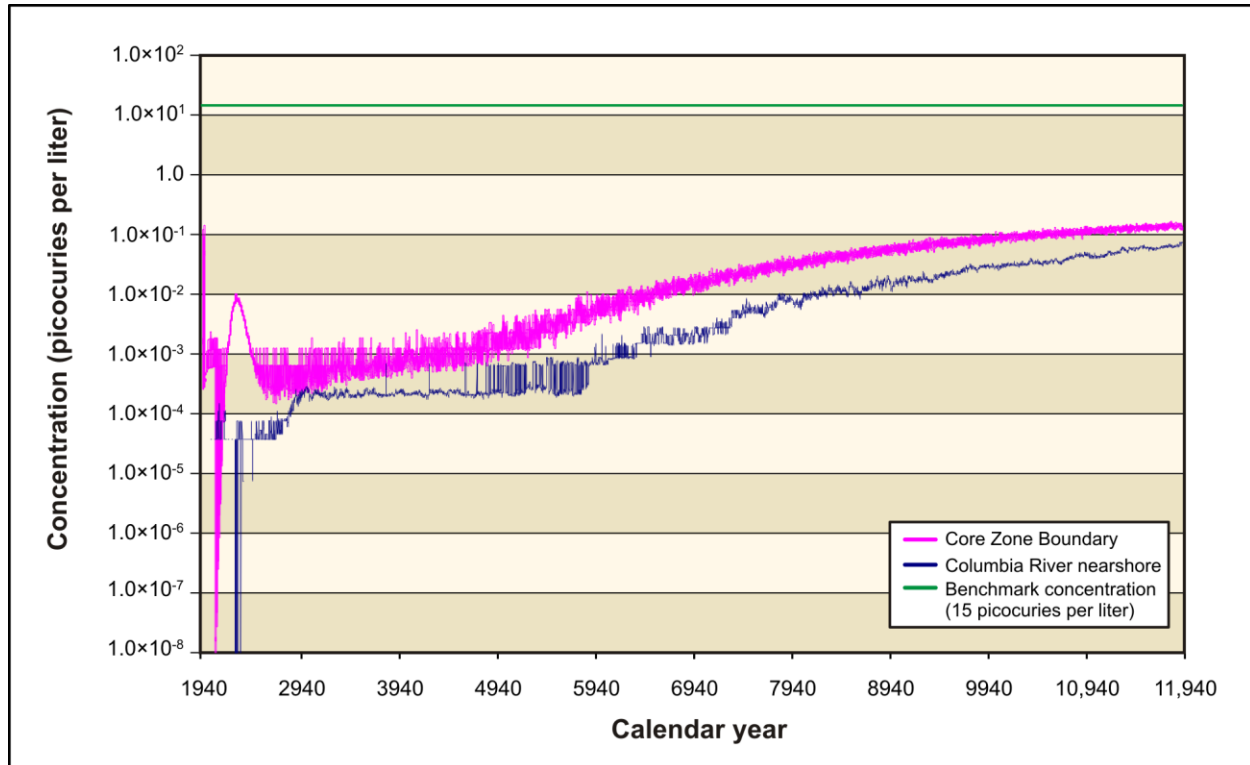


Figure 5-216. Tank Closure Alternative 6A, Option Case, Nitrate Concentration Versus Time

Figures 5–217 and 5–218 show concentration versus time for uranium-238 and total uranium under the Base Case. Although uranium-238 concentrations at the Core Zone Boundary begin to approach the benchmark concentration toward the latter part of the period of analysis, they never reach it. Total uranium concentrations at the Core Zone Boundary also begin to increase toward the end of the period of analysis but never come to within one order of magnitude of the benchmark. The concentration levels of uranium-238 and total uranium at the Columbia River nearshore never come to within about two orders of magnitude below the benchmark.



**Figure 5–217. Tank Closure Alternative 6A, Base Case, Uranium-238
Concentration Versus Time**

Under the Option Case, uranium-238 concentrations at the Core Zone Boundary peak at about two orders of magnitude below the benchmark at the beginning of the period of analysis (see Figure 5–219). Around CY 3000, the uranium-238 concentrations at the Core Zone Boundary drastically fall to over nine orders of magnitude below the benchmark, while the Columbia River nearshore concentrations of uranium-238 stay fairly constant at about five orders of magnitude below the benchmark. Total uranium concentrations are essentially identical to uranium-238 concentrations (see Figure 5–220).

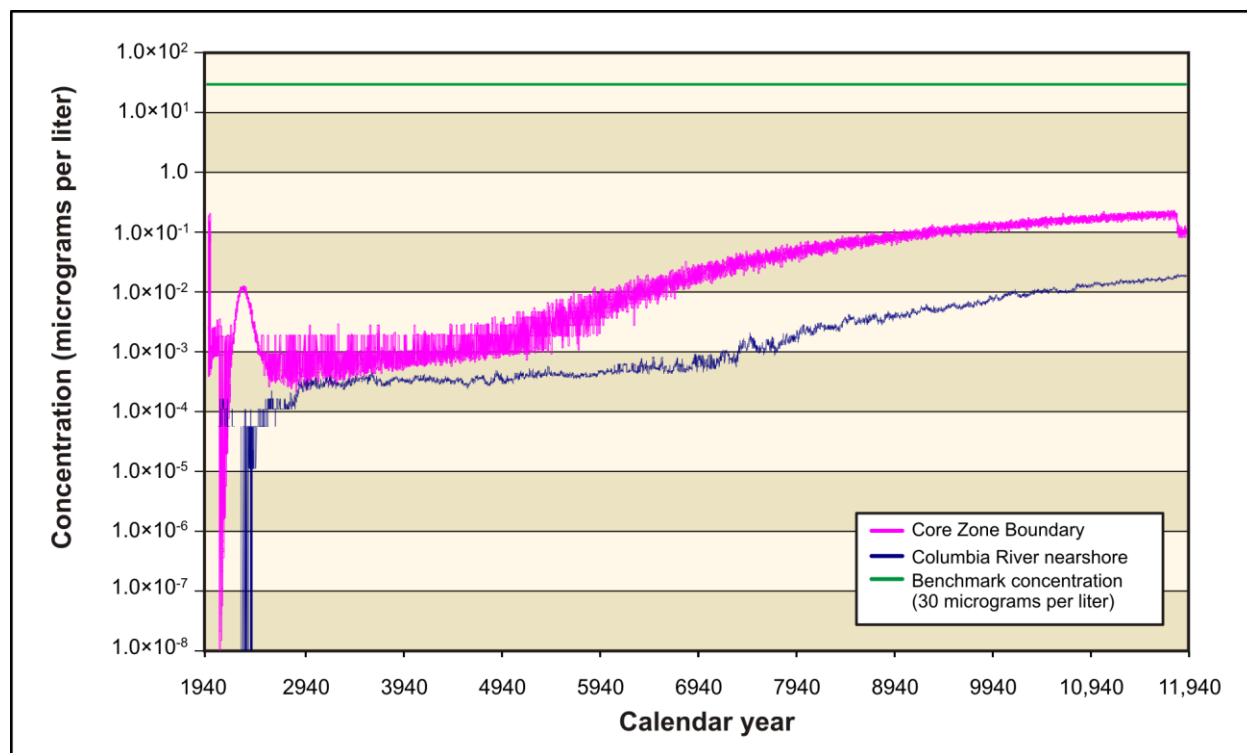


Figure 5-218. Tank Closure Alternative 6A, Base Case, Total Uranium Concentration Versus Time

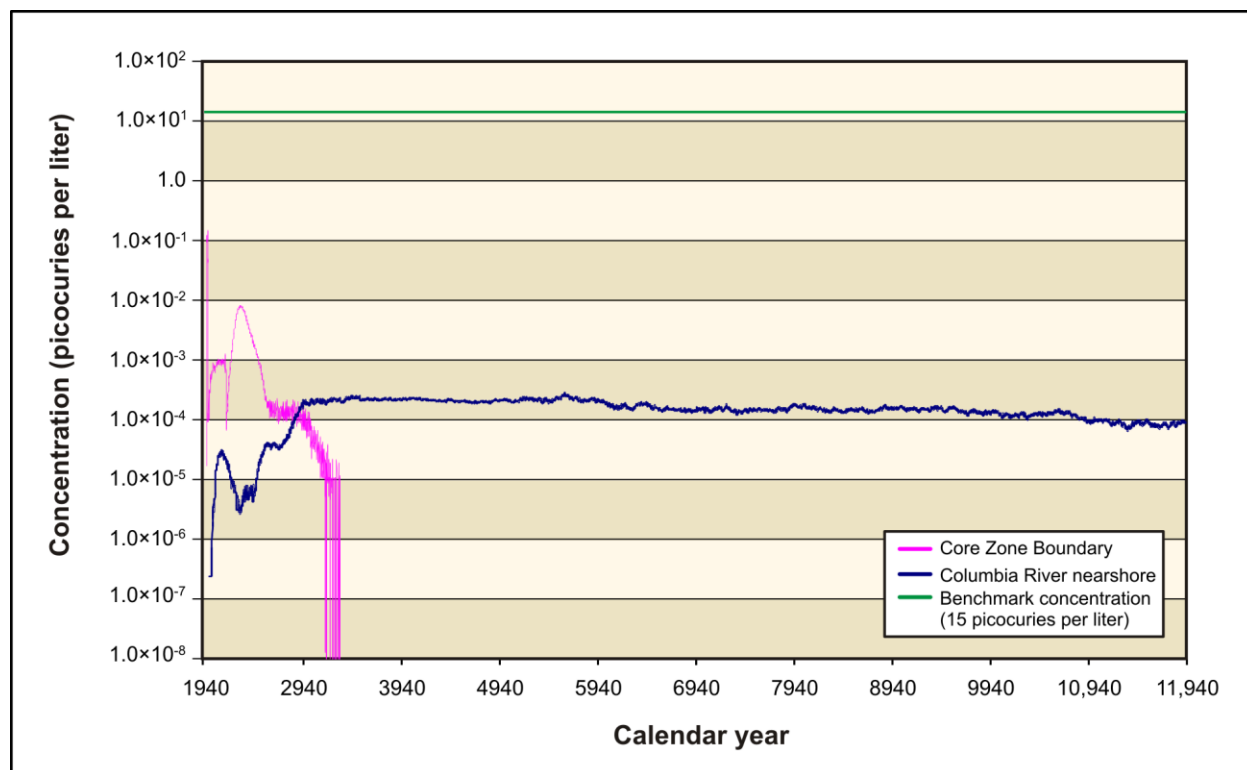


Figure 5-219. Tank Closure Alternative 6A, Option Case, Uranium-238 Concentration Versus Time

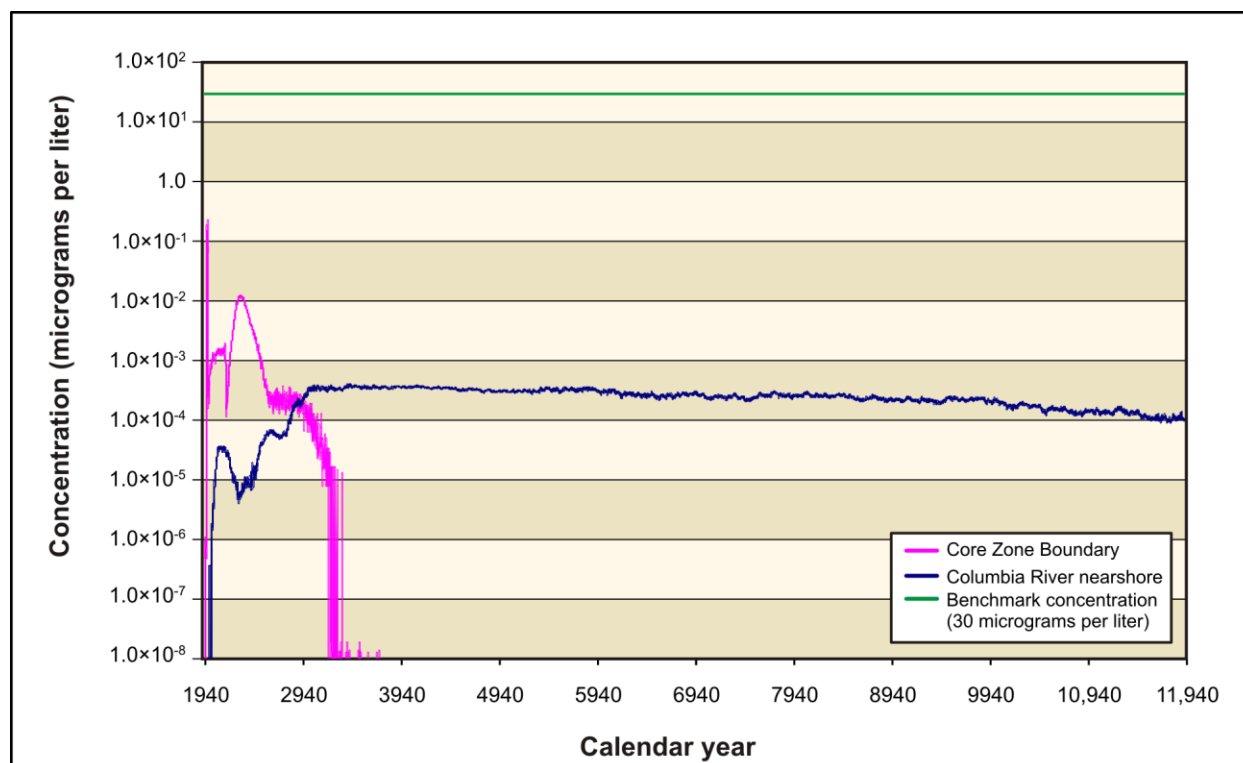


Figure 5-220. Tank Closure Alternative 6A, Option Case, Total Uranium Concentration Versus Time

5.1.1.9.5 Analysis of Spatial Distribution of Concentration

This section presents the impacts of Tank Closure Alternative 6A in terms of the spatial distribution of COPC driver concentrations in groundwater at selected times. Concentrations of radionuclides are in picocuries per liter; chemicals, in micrograms per liter (see Figures 5-221 through 5-262). Concentrations of each radionuclide and chemical are indicated by a color scale that is relative to the benchmark concentration. Concentrations greater than the benchmark concentration are indicated by the fully saturated colors green, yellow, orange, and red in order of increasing concentration. Concentrations less than the benchmark concentration are indicated by the faded colors green, blue, indigo, and violet in order of decreasing concentration. Note that the concentration ranges are on a logarithmic scale to facilitate visual comparison of concentrations that vary over three orders of magnitude.

Figure 5-221 shows the spatial distribution of tritium concentrations in groundwater in CY 2010 under the Base Case, which would include use of a modified RCRA Subtitle C barrier. Releases from cribs and trenches (ditches) and past leaks, associated primarily with the T, TX, and TY tank farms, result in a groundwater concentration plume (exceeding the benchmark concentration) that extends from the center part of the 200-West Area northeast, crosses the Core Zone Boundary, and continues toward Gable Gap. Peak concentrations in this plume are about 5 to 10 times greater than the benchmark concentration. The overall tritium concentrations are attenuated by radioactive decay to levels less than one-twentieth of the benchmark concentration by CY 2135 (see Figure 5-222).

The spatial distribution of tritium concentrations in groundwater in CY 2010 and CY 2135 under the Option Case, which would include removal of the six sets of cribs and trenches (ditches) and remediation of their plumes within the vadose zone, is essentially identical to that under the Base Case (see Figures 5-223 and 5-224).

Figure 5–225 shows the spatial distribution of iodine-129 concentrations in groundwater in CY 2010 under the Base Case. Releases from cribs and trenches (ditches) and past leaks result in groundwater concentration plumes that are at or exceed the benchmark concentration at the B, S, and T Barriers. Peak concentrations in this plume are about 10 to 50 times greater than the benchmark and are mostly contained within the Core Zone Boundary. By CY 2135, the contaminant plumes have spread further north through Gable Gap and further east toward the Columbia River (see Figure 5–226). In the plume north of Gable Gap, contaminant levels are 10 to 50 times greater than the benchmark concentration. In the east, just outside of the Core Zone Boundary, peak concentration levels are up to 5 times greater than the benchmark. By CY 7140, most of the mass in the plume has reached the Columbia River, with concentrations less than one-twentieth of the benchmark (see Figure 5–227). Technetium-99 (see Figures 5–228 through 5–230), chromium (see Figures 5–231 through 5–233), and nitrate (see Figures 5–234 through 5–236) show similar spatial distributions at selected times. Iodine-129, technetium-99, chromium, and nitrate are all conservative tracers (i.e., move at the rate of the pore-water velocity) during the period of analysis.

The spatial distribution of groundwater concentrations of the conservative tracers under the Option Case is essentially identical to that under the Base Case (see Figures 5–237 through 5–248).

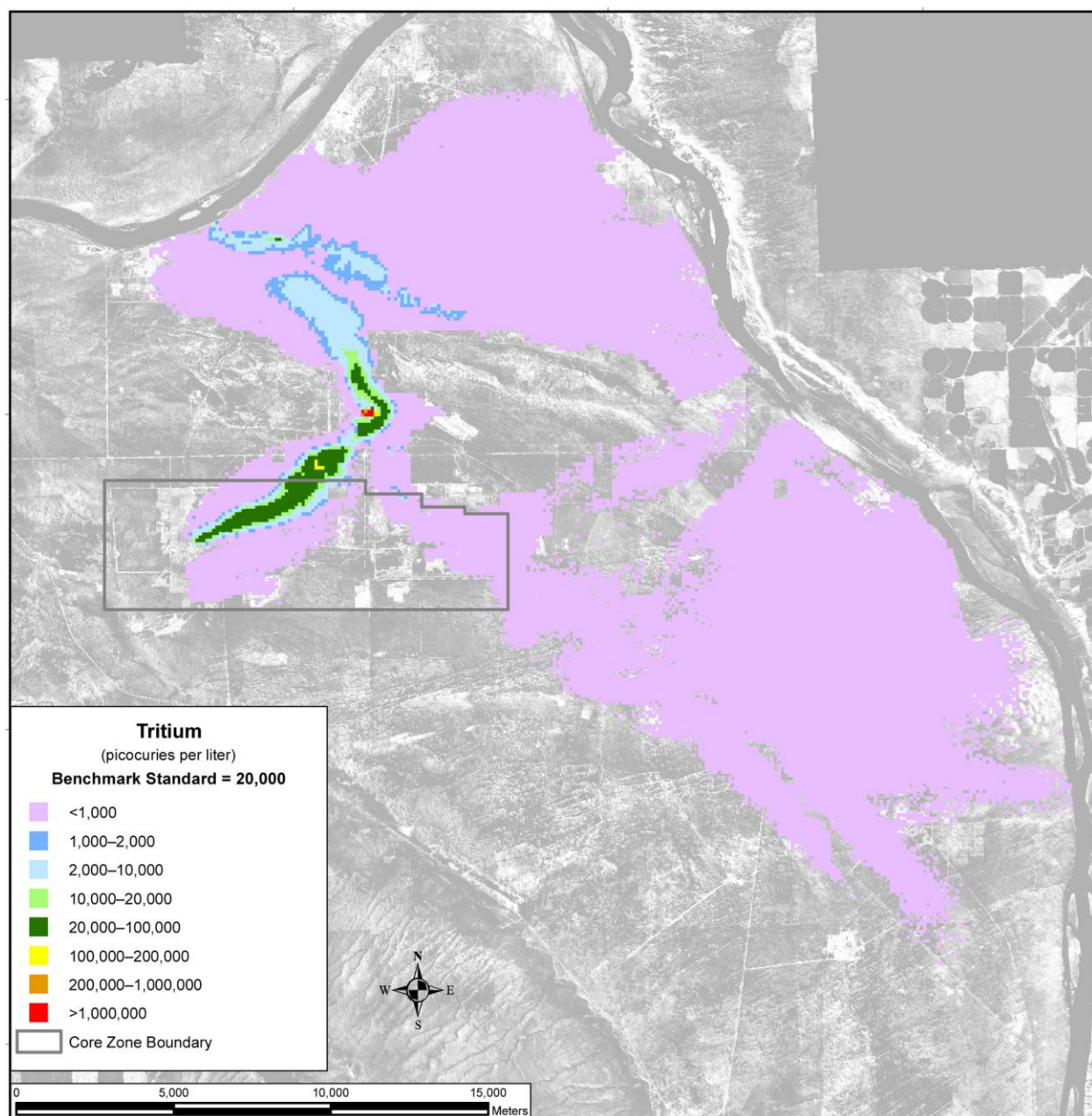
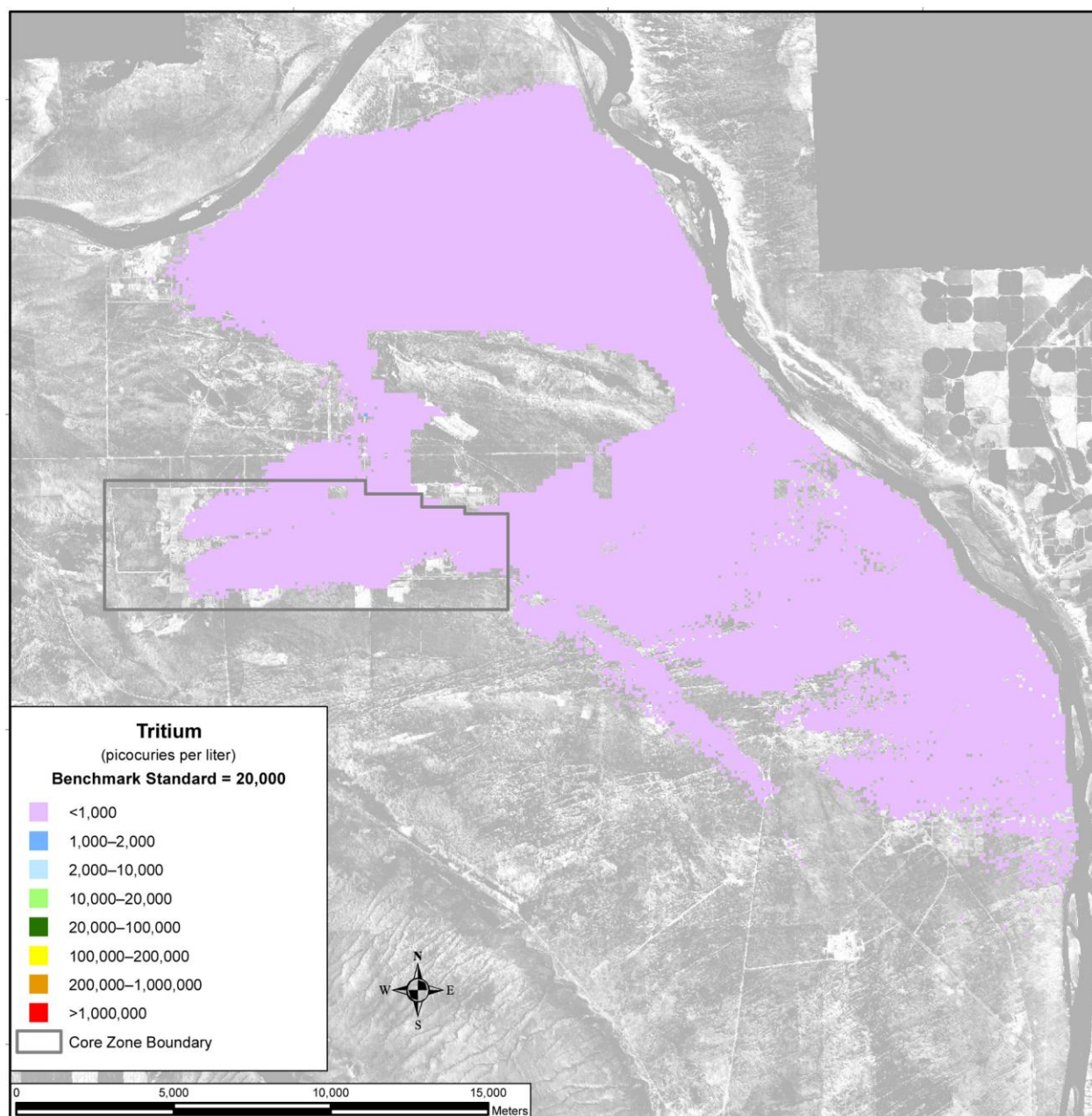
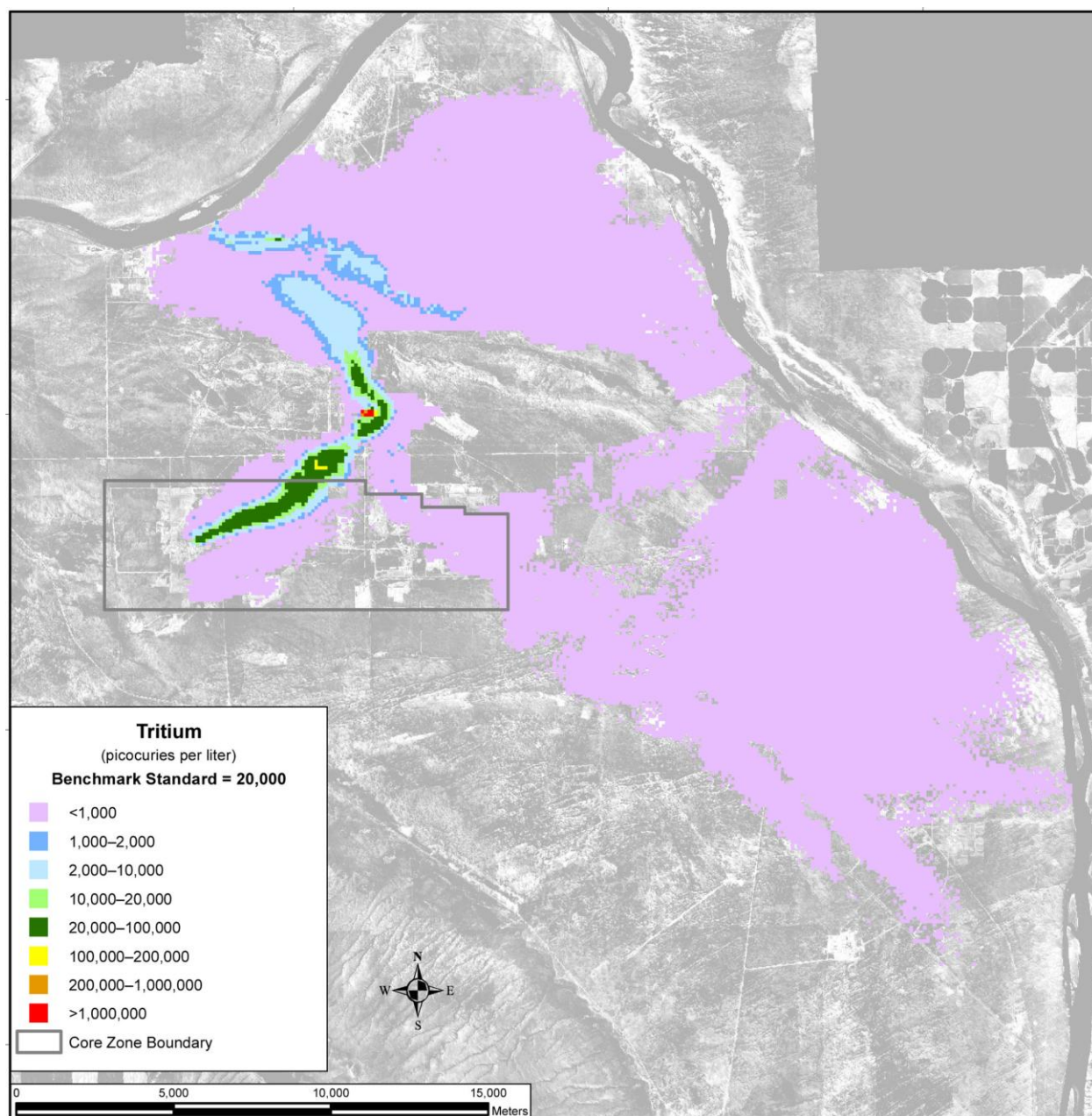


Figure 5–221. Tank Closure Alternative 6A, Base Case, Spatial Distribution of Groundwater Hydrogen-3 (Tritium) Concentration, Calendar Year 2010

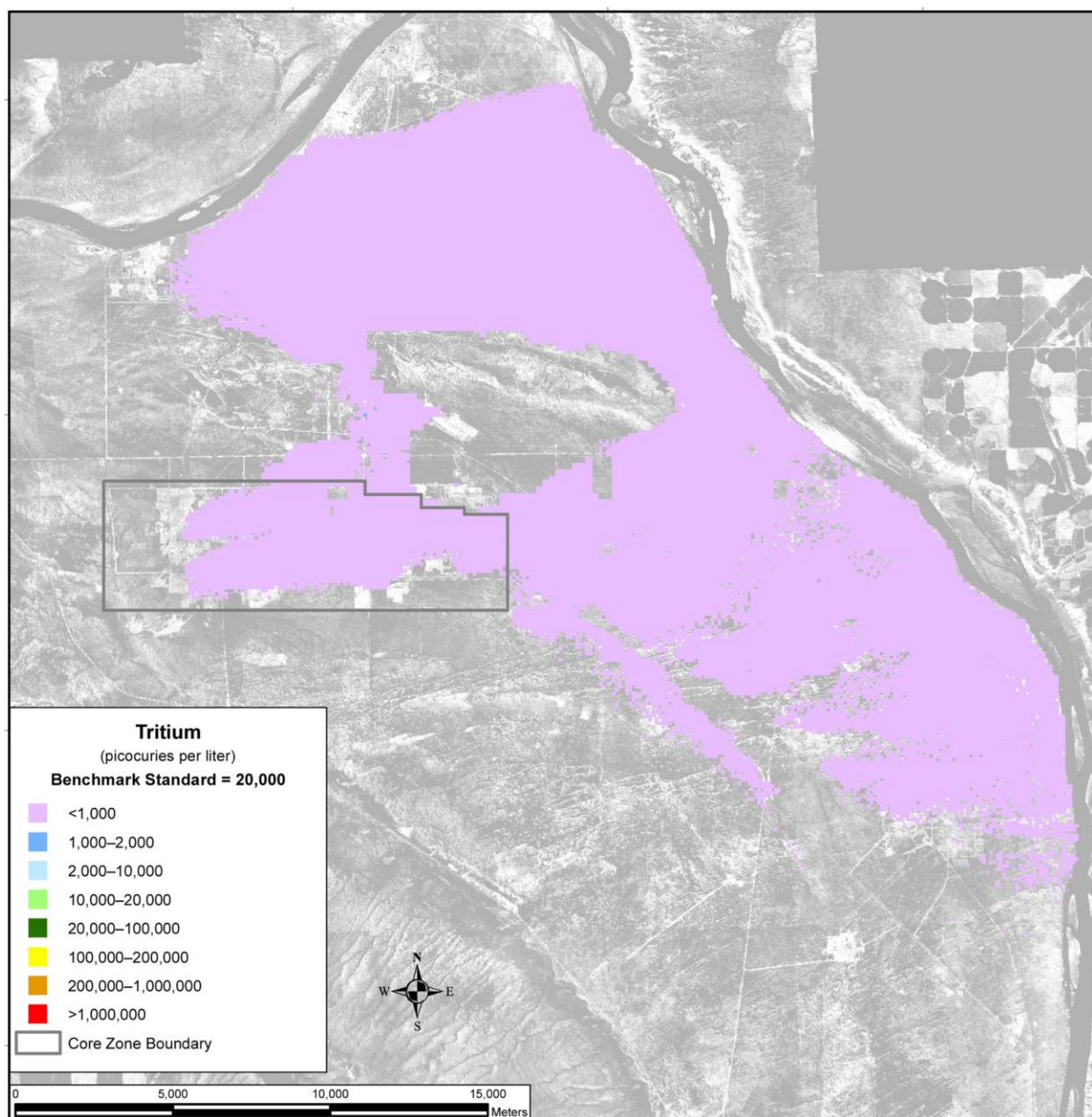


Note: To convert meters to feet, multiply by 3.281.

Figure 5–222. Tank Closure Alternative 6A, Base Case, Spatial Distribution of Groundwater Hydrogen-3 (Tritium), Concentration, Calendar Year 2135



**Figure 5–223. Tank Closure Alternative 6A, Option Case, Spatial Distribution of Groundwater
Hydrogen-3 (Tritium) Concentration, Calendar Year 2010**



Note: To convert meters to feet, multiply by 3.281.

Figure 5–224. Tank Closure Alternative 6A, Option Case, Spatial Distribution of Groundwater Hydrogen-3 (Tritium) Concentration, Calendar Year 2135

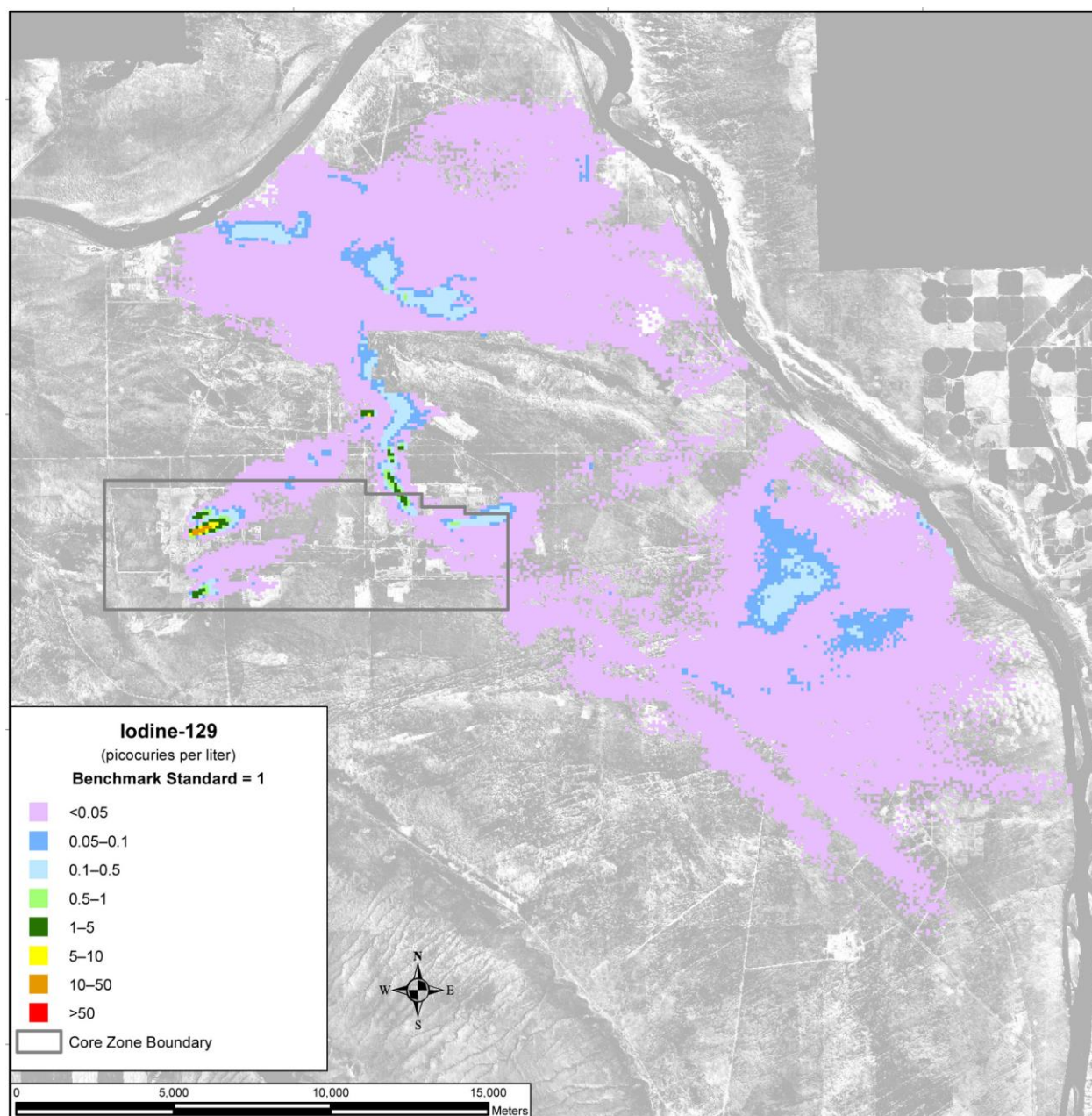
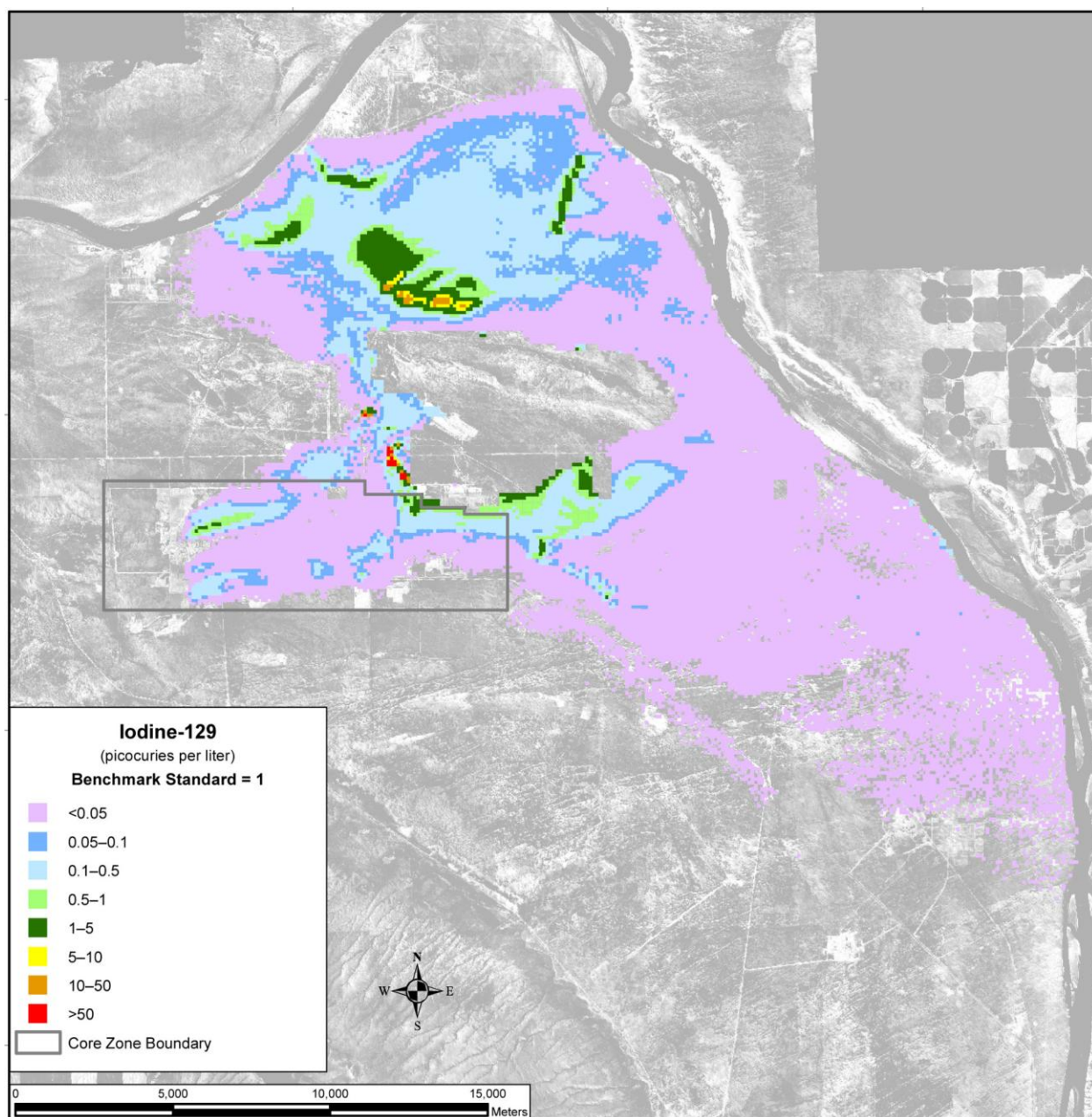
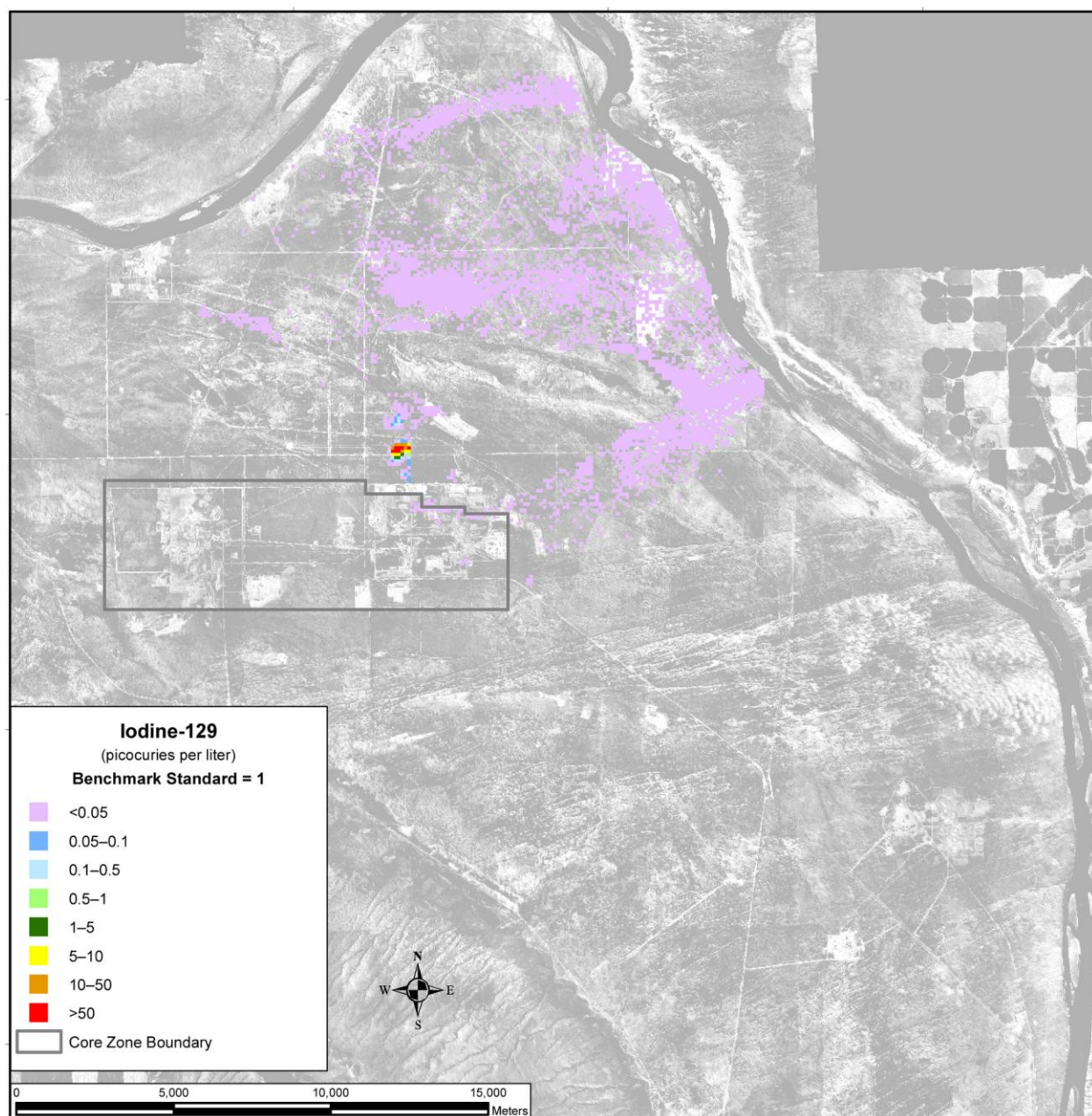


Figure 5–225. Tank Closure Alternative 6A, Base Case, Spatial Distribution of Groundwater Iodine-129 Concentration, Calendar Year 2010



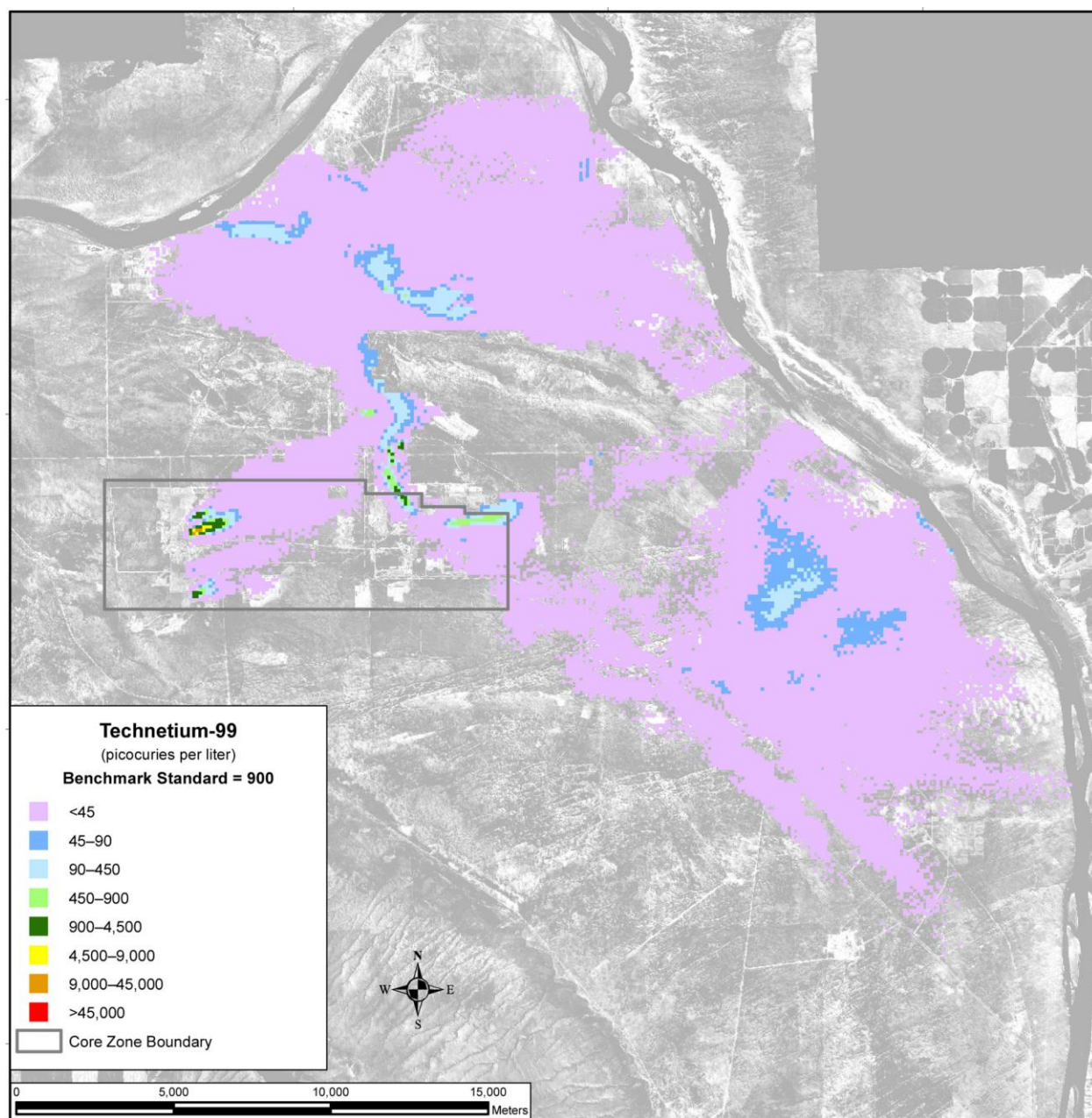
Note: To convert meters to feet, multiply by 3.281.

Figure 5–226. Tank Closure Alternative 6A, Base Case, Spatial Distribution of Groundwater Iodine-129 Concentration, Calendar Year 2135



Note: To convert meters to feet, multiply by 3.281.

Figure 5–227. Tank Closure Alternative 6A, Base Case, Spatial Distribution of Groundwater Iodine-129 Concentration, Calendar Year 7140



Note: To convert meters to feet, multiply by 3.281.

Figure 5–228. Tank Closure Alternative 6A, Base Case, Spatial Distribution of Groundwater Technetium-99 Concentration, Calendar Year 2010

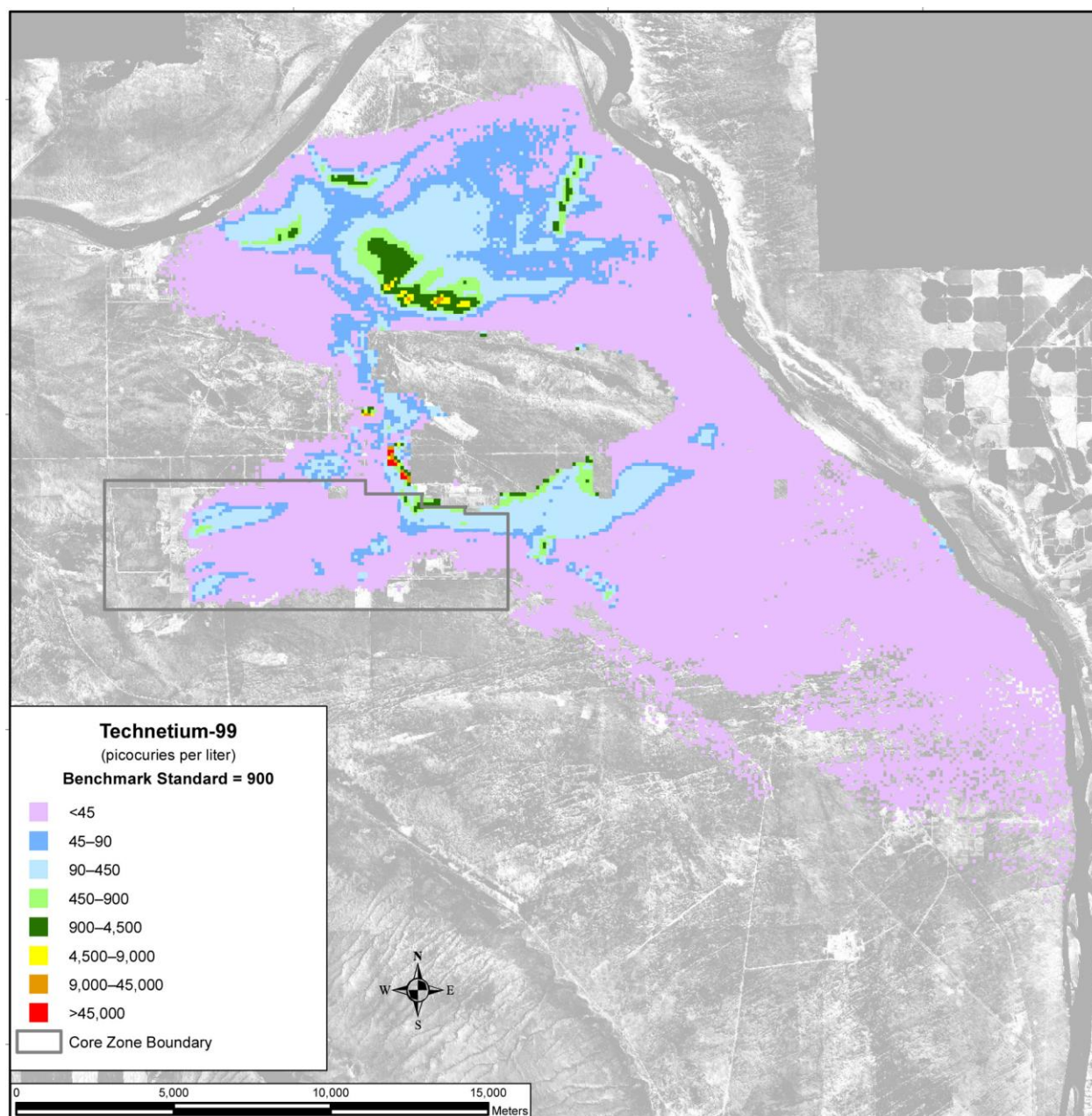
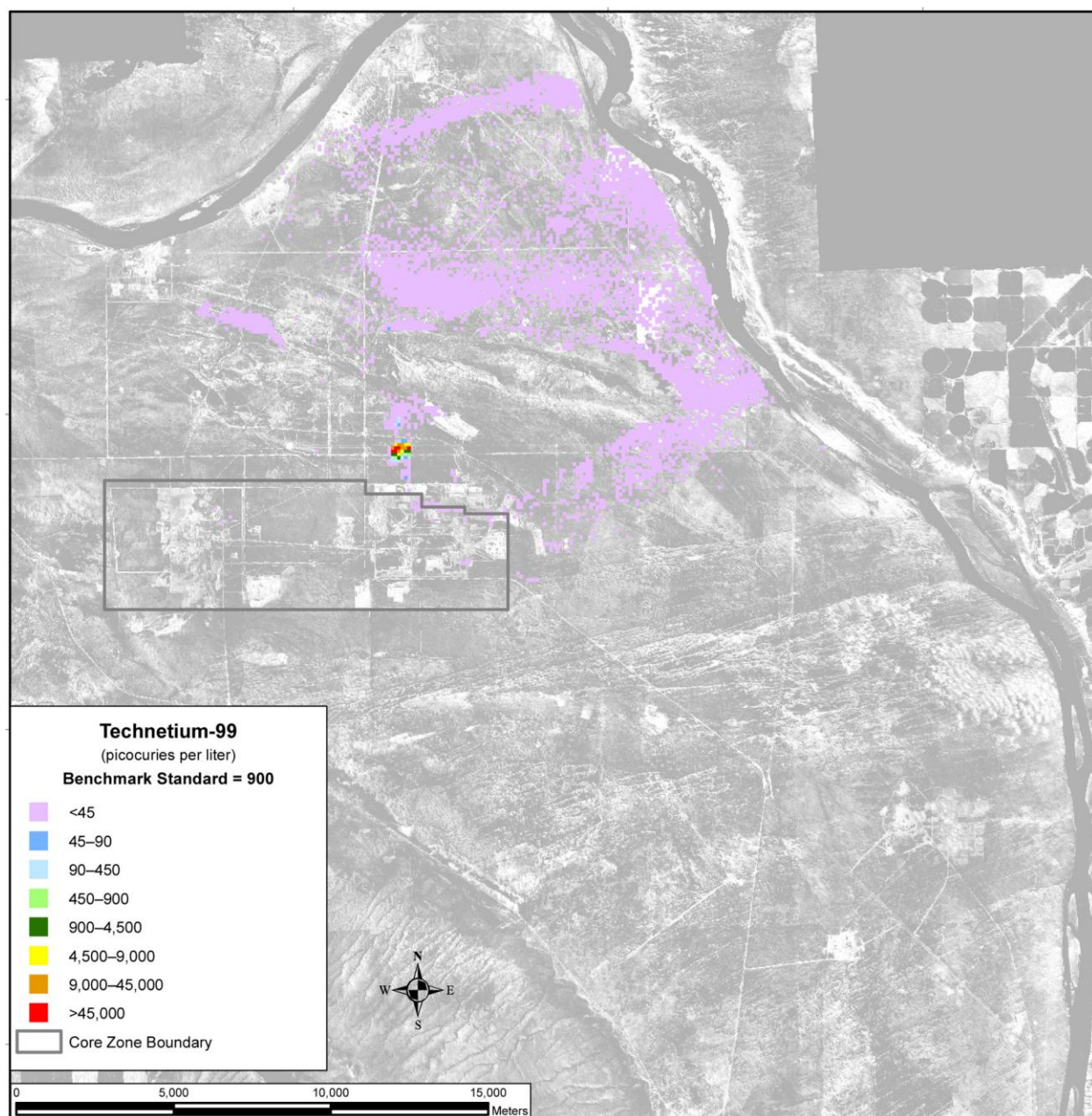
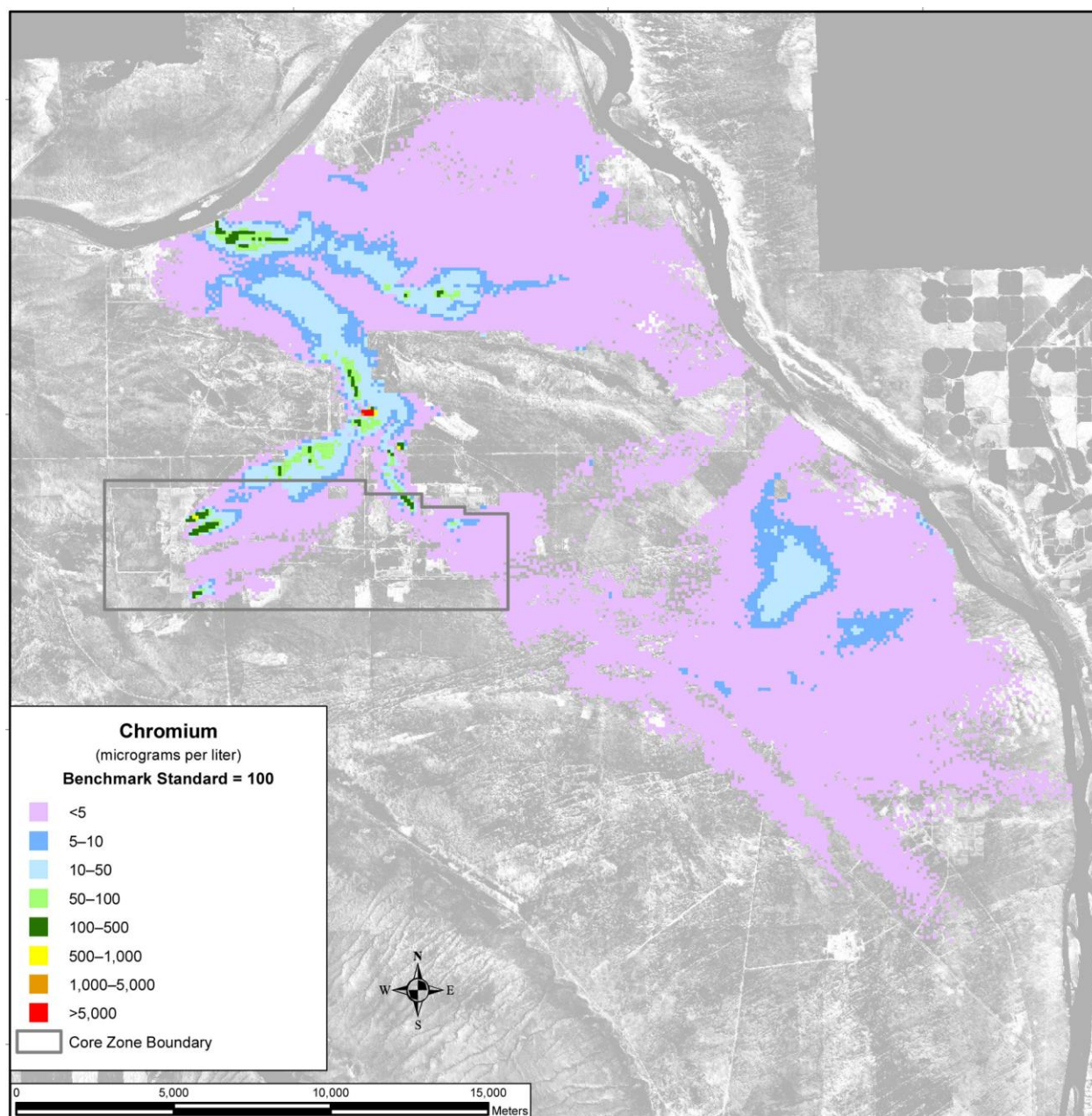


Figure 5–229. Tank Closure Alternative 6A, Base Case, Spatial Distribution of Groundwater Technetium-99 Concentration, Calendar Year 2135



Note: To convert meters to feet, multiply by 3.281.

Figure 5-230. Tank Closure Alternative 6A, Base Case, Spatial Distribution of Groundwater Technetium-99 Concentration, Calendar Year 7140



Note: To convert meters to feet, multiply by 3.281.

Figure 5-231. Tank Closure Alternative 6A, Base Case, Spatial Distribution of Groundwater Chromium Concentration, Calendar Year 2010

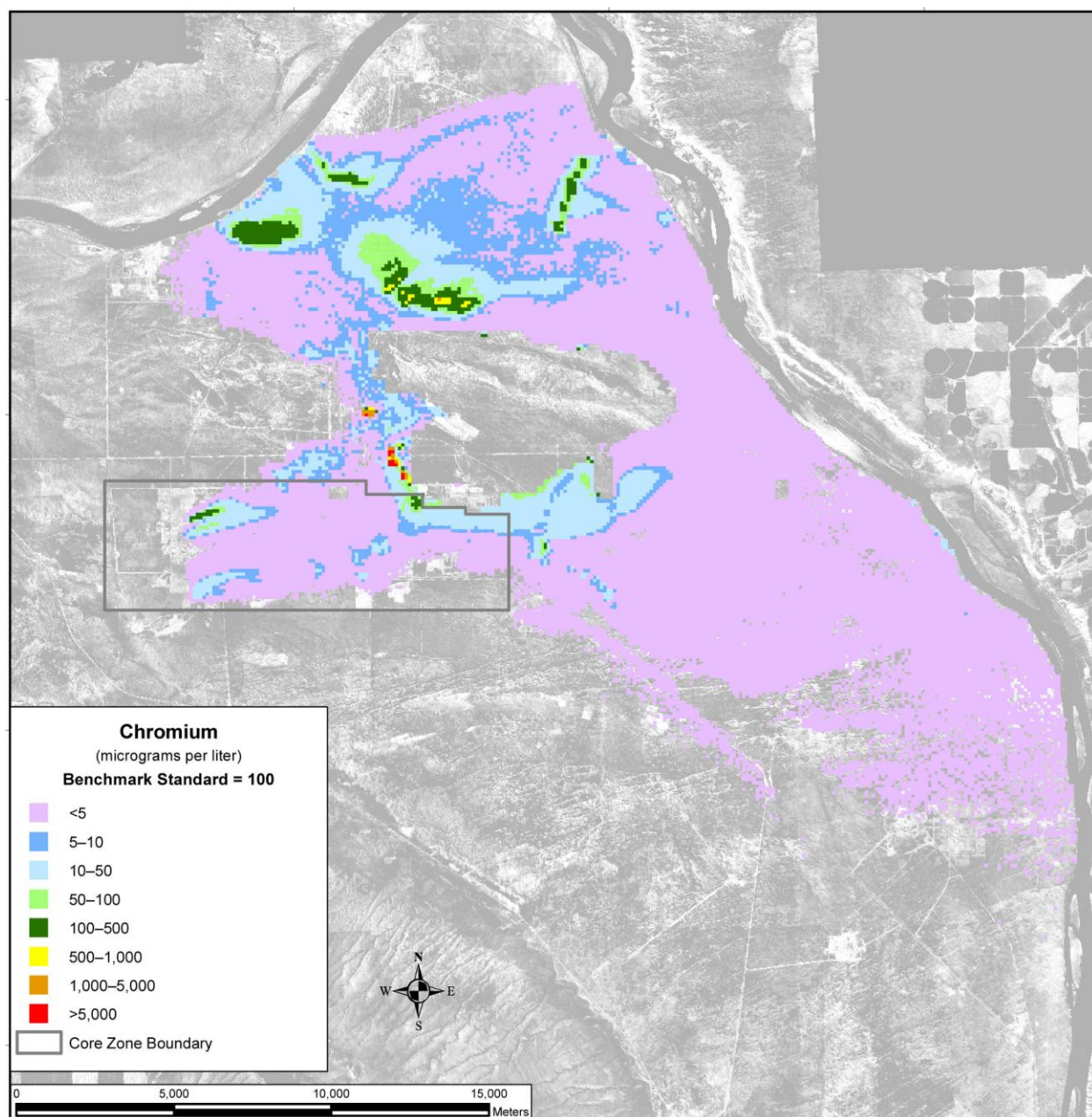


Figure 5–232. Tank Closure Alternative 6A, Base Case, Spatial Distribution of Groundwater Chromium Concentration, Calendar Year 2135

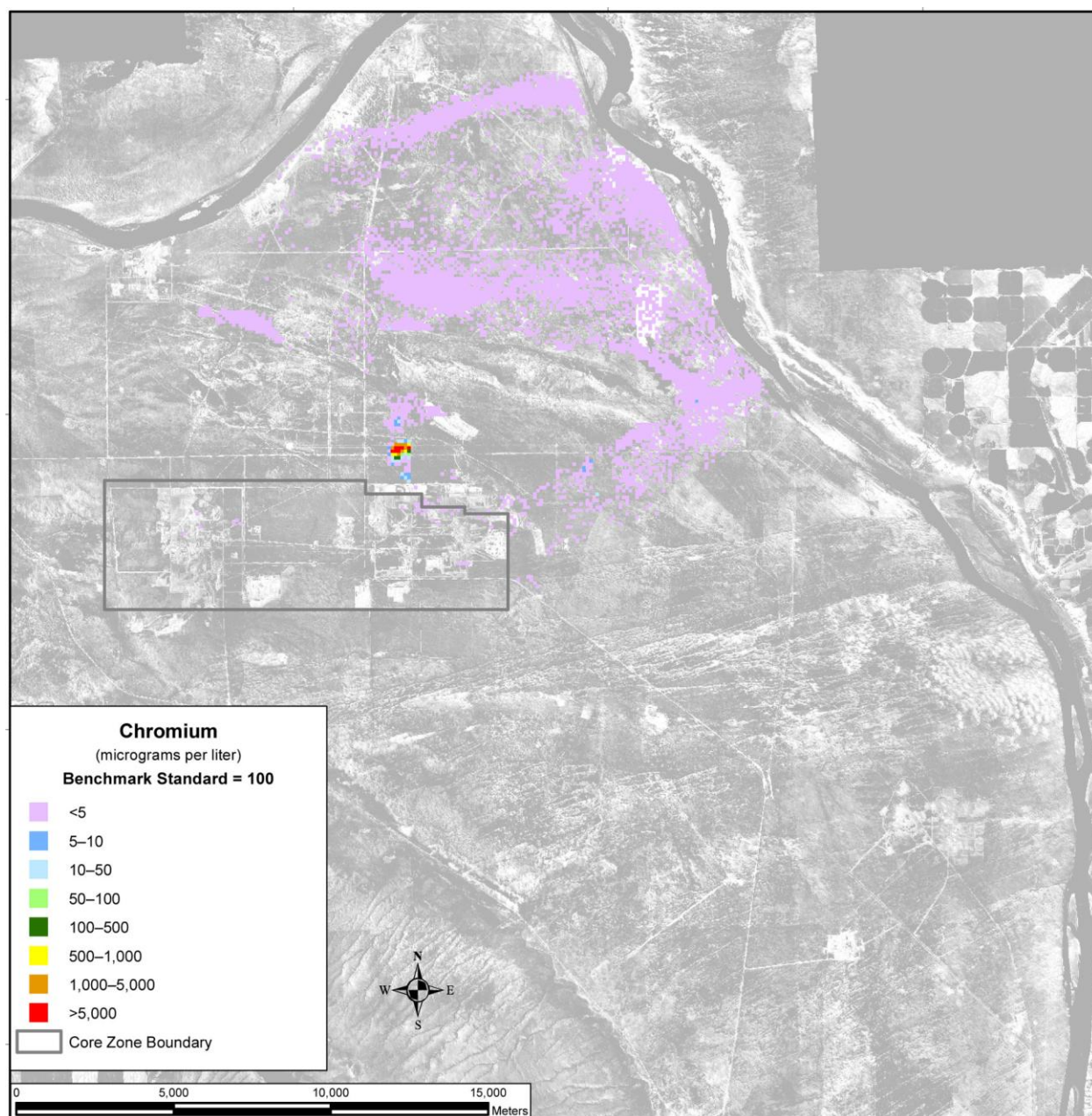


Figure 5–233. Tank Closure Alternative 6A, Base Case, Spatial Distribution of Groundwater Chromium Concentration, Calendar Year 7140

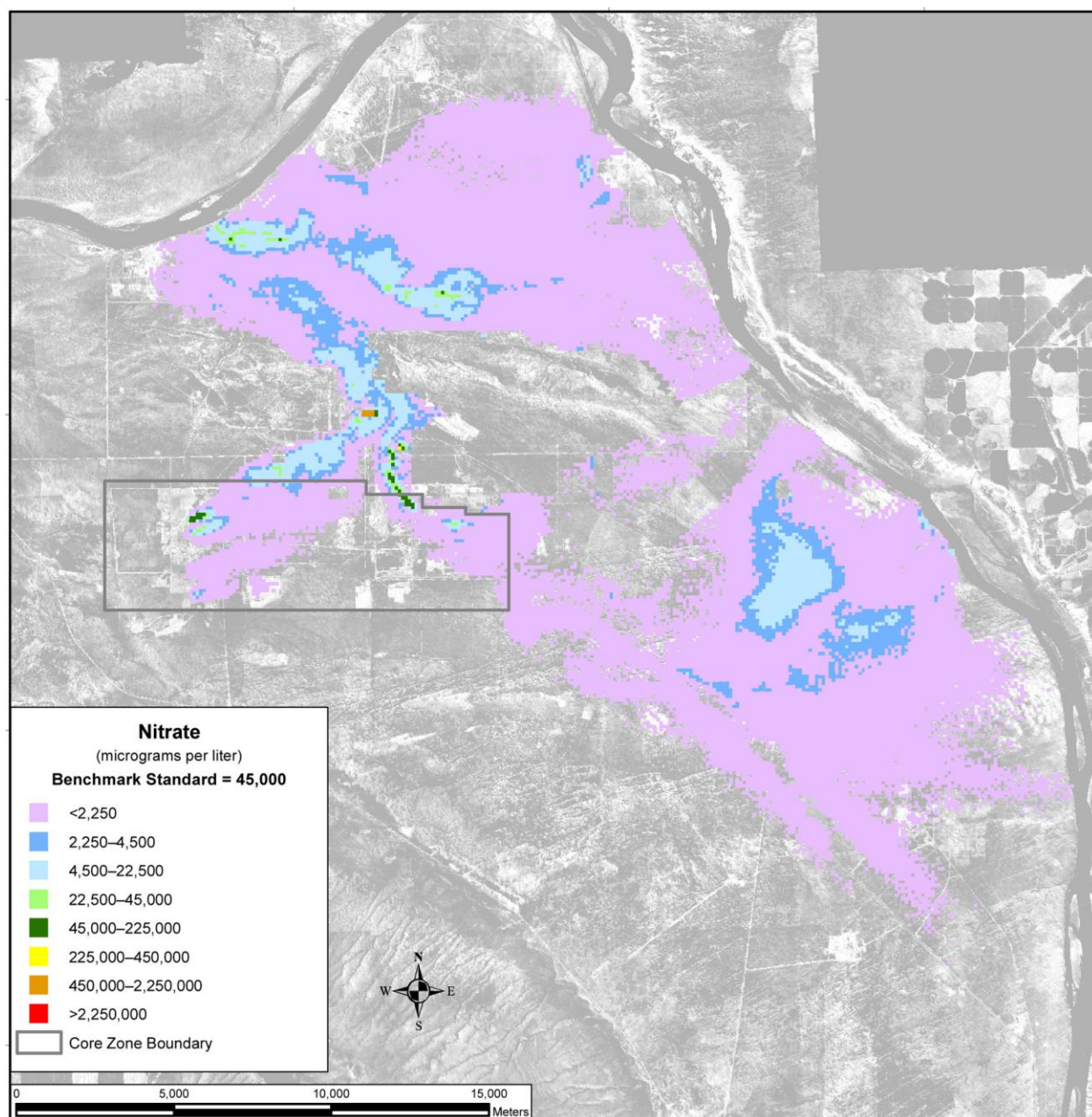
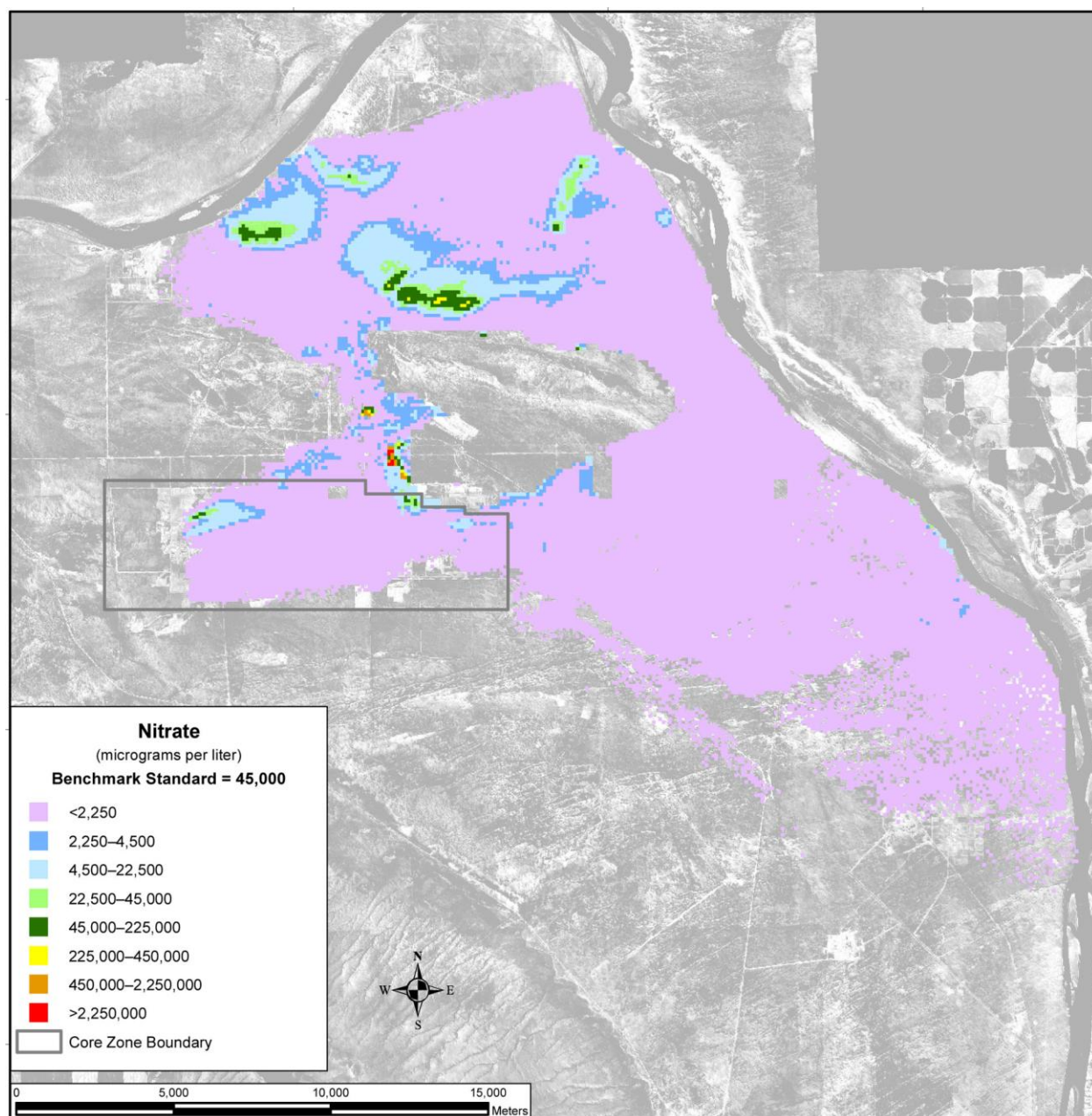
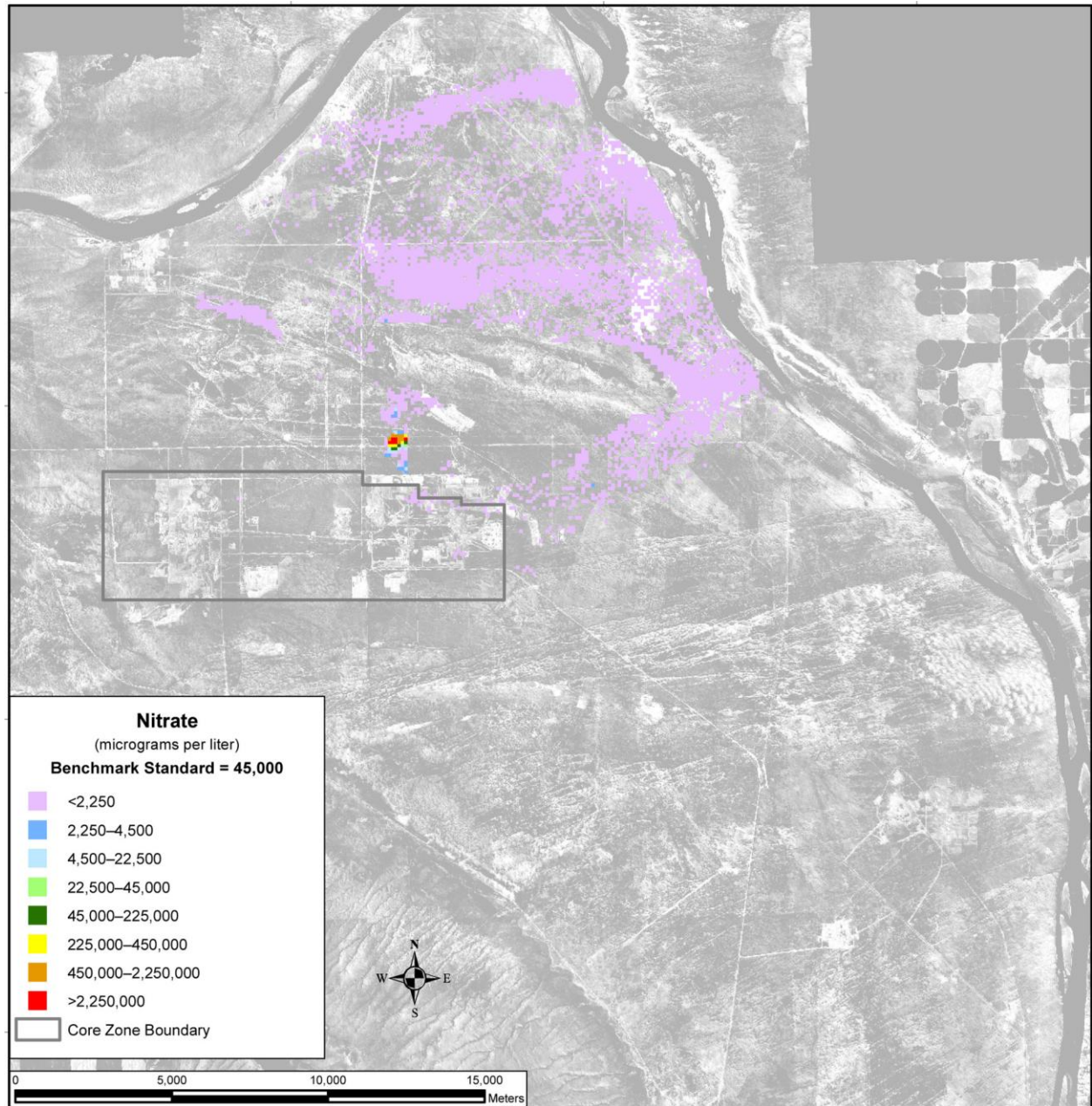


Figure 5–234. Tank Closure Alternative 6A, Base Case, Spatial Distribution of Groundwater Nitrate Concentration, Calendar Year 2010



Note: To convert meters to feet, multiply by 3.281.

Figure 5–235. Tank Closure Alternative 6A, Base Case, Spatial Distribution of Groundwater Nitrate Concentration, Calendar Year 2135



Note: To convert meters to feet, multiply by 3.281.

Figure 5–236. Tank Closure Alternative 6A, Base Case, Spatial Distribution of Groundwater Nitrate Concentration, Calendar Year 7140

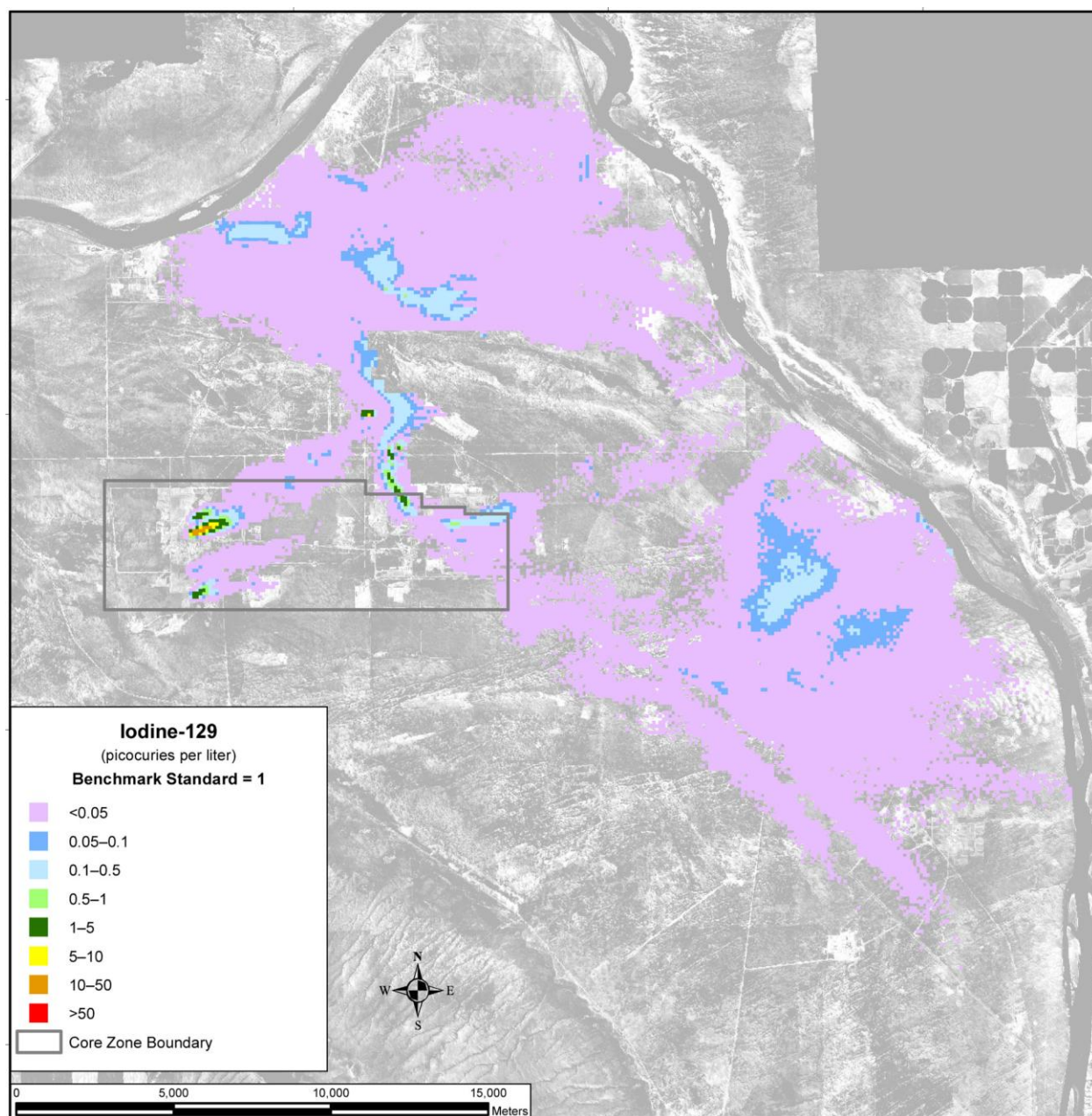
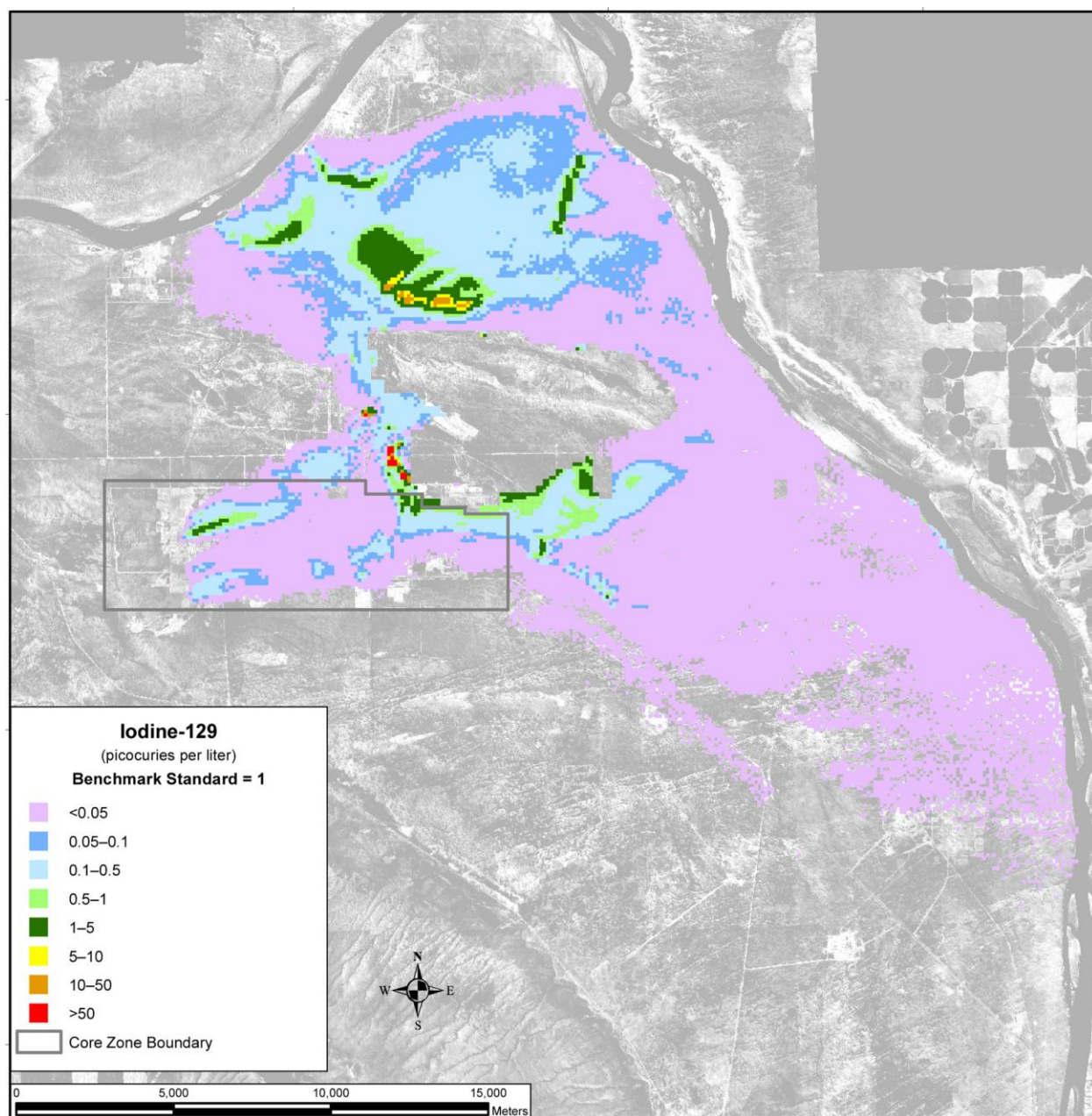


Figure 5–237. Tank Closure Alternative 6A, Option Case, Spatial Distribution of Groundwater Iodine-129 Concentration, Calendar Year 2010



Note: To convert meters to feet, multiply by 3.281.

Figure 5–238. Tank Closure Alternative 6A, Option Case, Spatial Distribution of Groundwater Iodine-129 Concentration, Calendar Year 2135

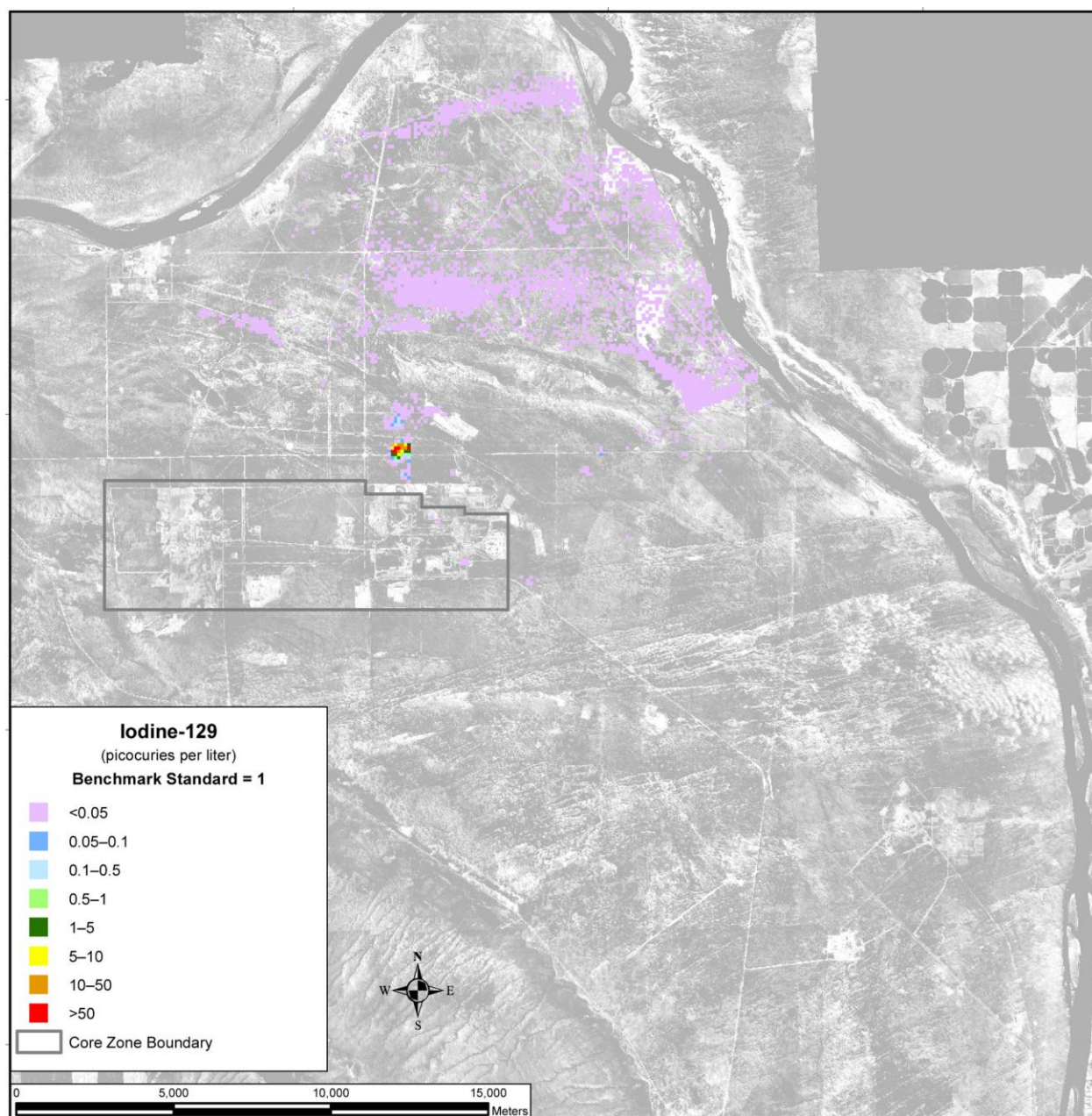
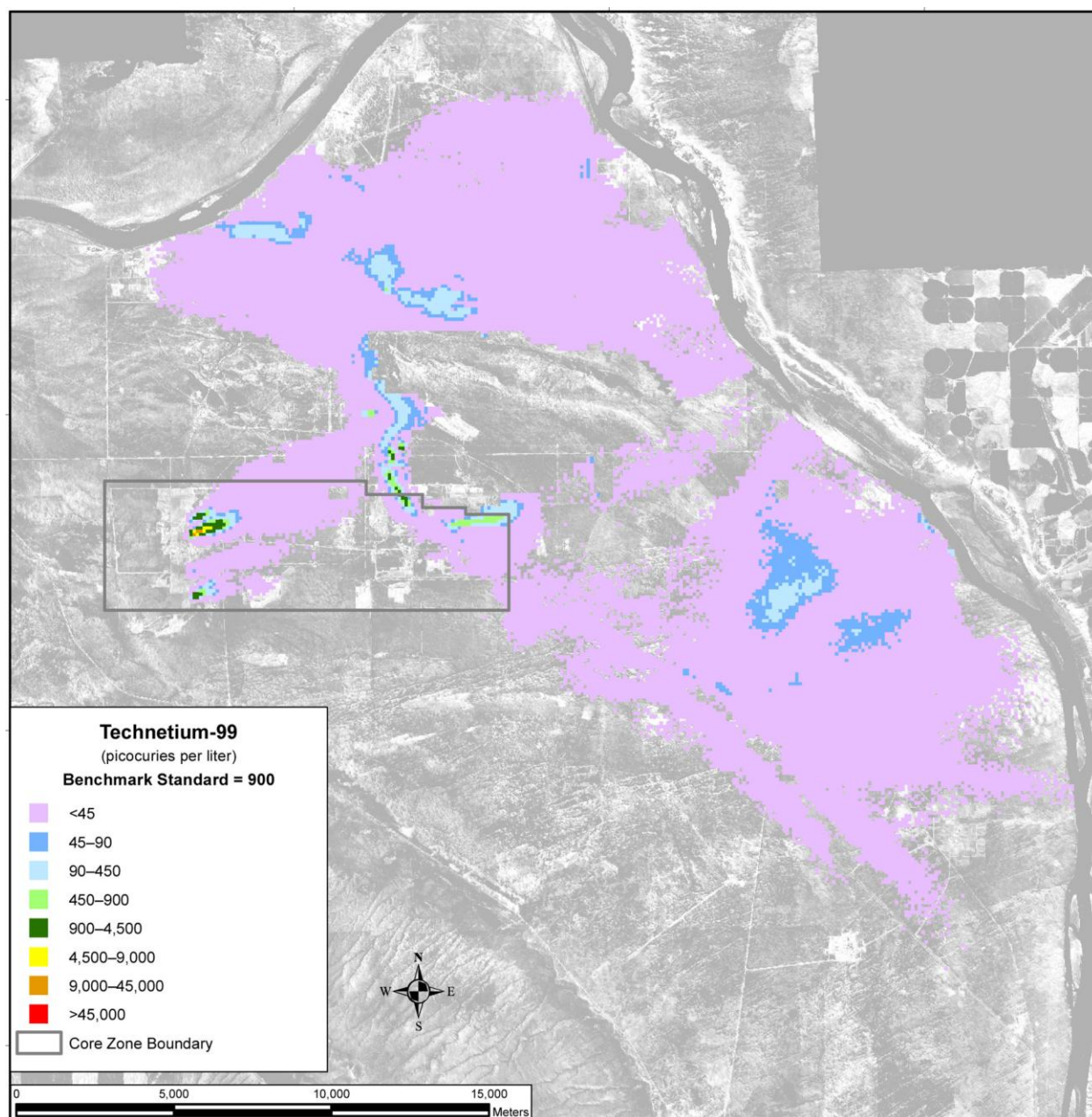
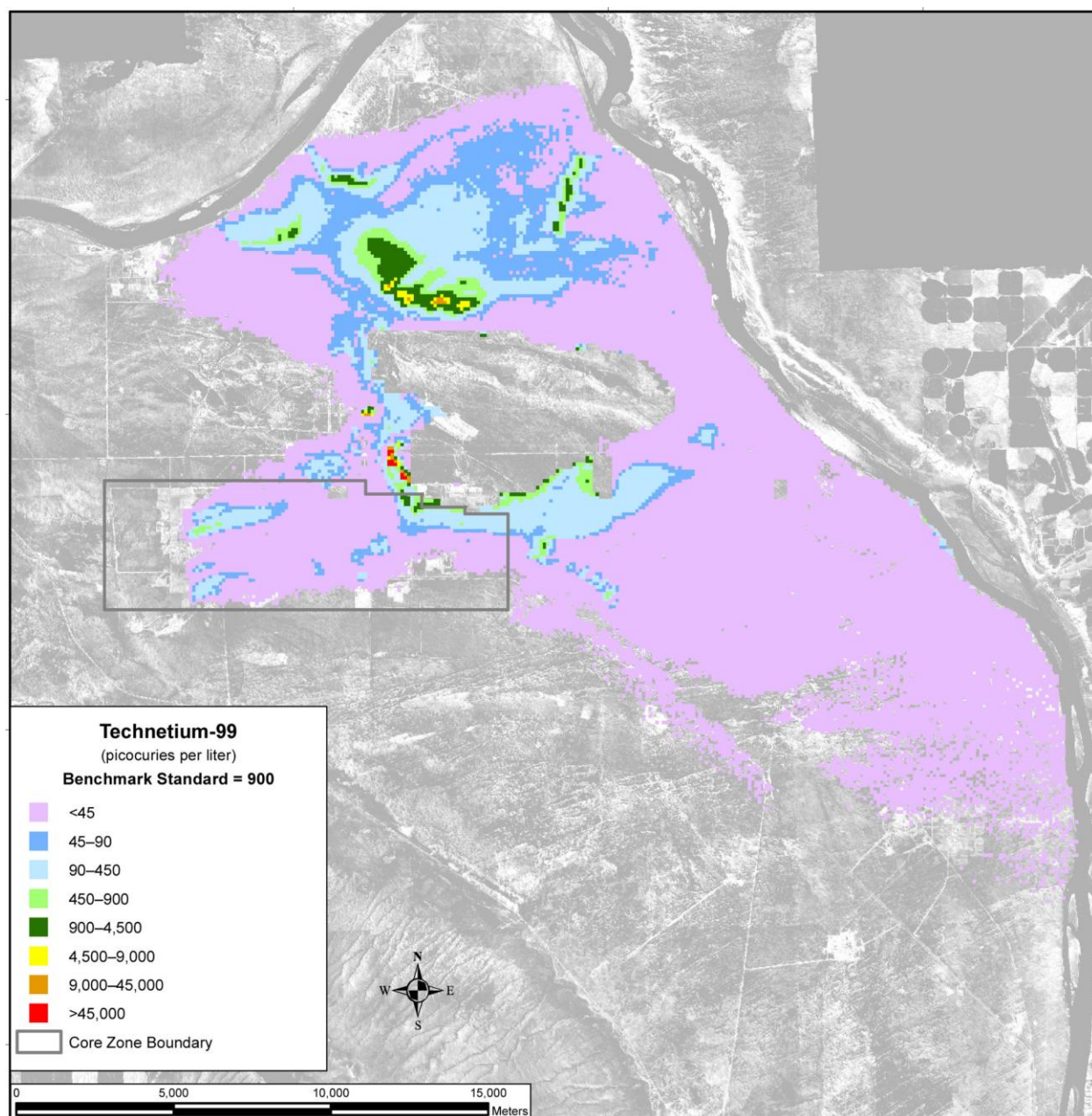


Figure 5–239. Tank Closure Alternative 6A, Option Case, Spatial Distribution of Groundwater Iodine-129 Concentration, Calendar Year 7140

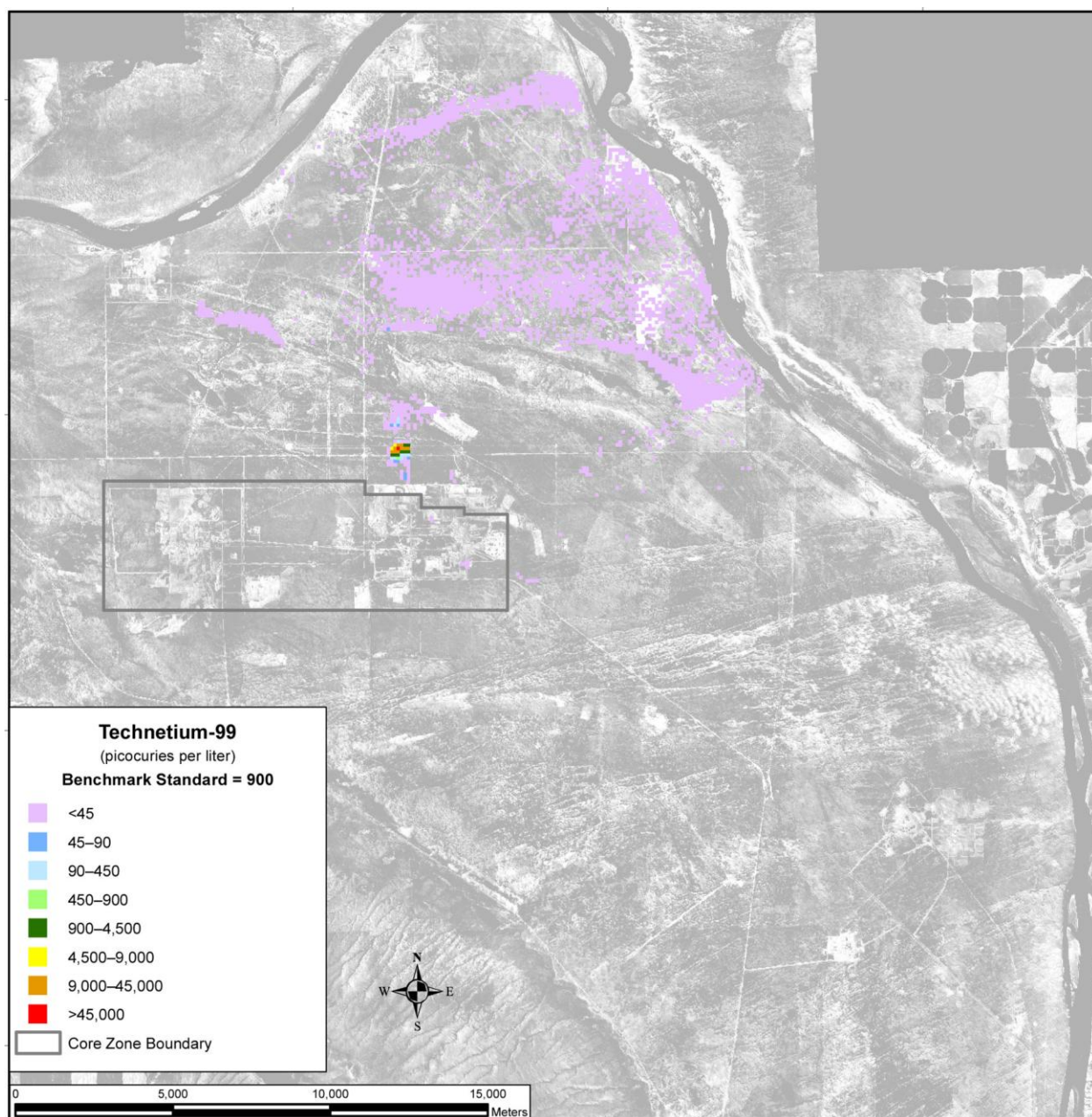


Note: To convert meters to feet, multiply by 3.281.

Figure 5–240. Tank Closure Alternative 6A, Option Case, Spatial Distribution of Groundwater Technetium-99 Concentration, Calendar Year 2010



**Figure 5–241. Tank Closure Alternative 6A, Option Case, Spatial Distribution of Groundwater
Technetium-99 Concentration, Calendar Year 2135**



Note: To convert meters to feet, multiply by 3.281.

Figure 5–242. Tank Closure Alternative 6A, Option Case, Spatial Distribution of Groundwater Technetium-99 Concentration, Calendar Year 7140

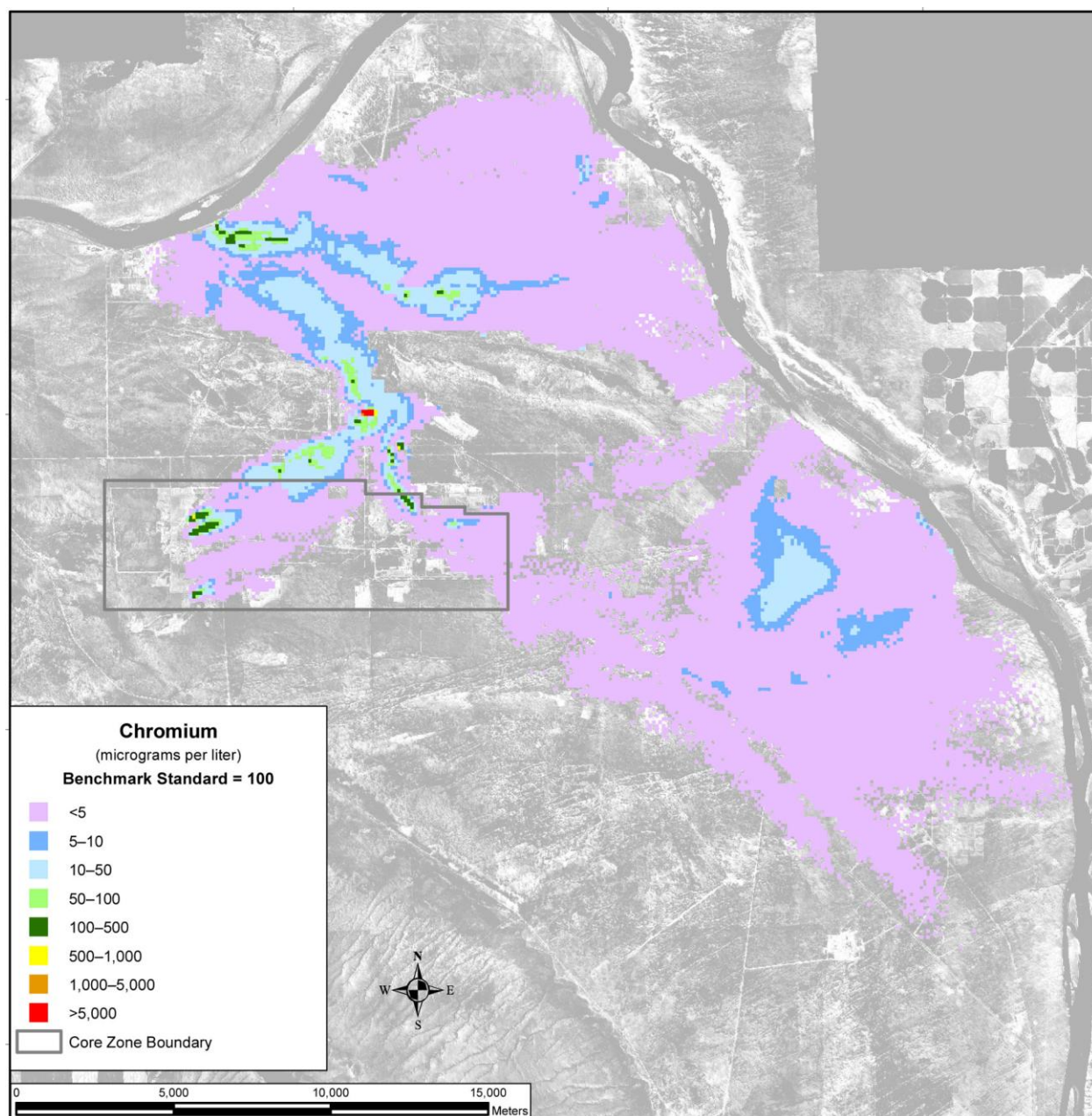


Figure 5–243. Tank Closure Alternative 6A, Option Case, Spatial Distribution of Groundwater Chromium Concentration, Calendar Year 2010

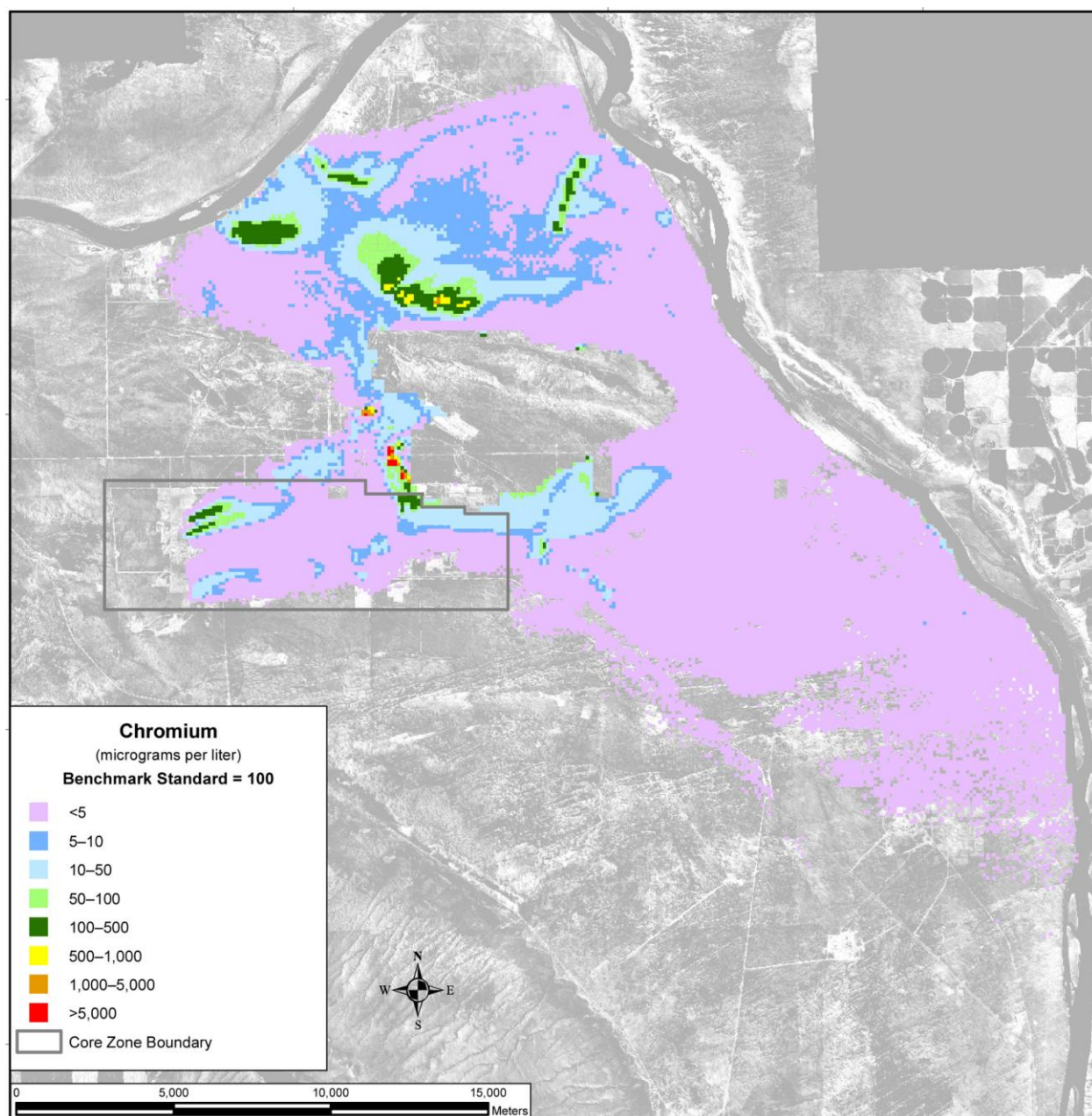


Figure 5–244. Tank Closure Alternative 6A, Option Case, Spatial Distribution of Groundwater Chromium Concentration, Calendar Year 2135

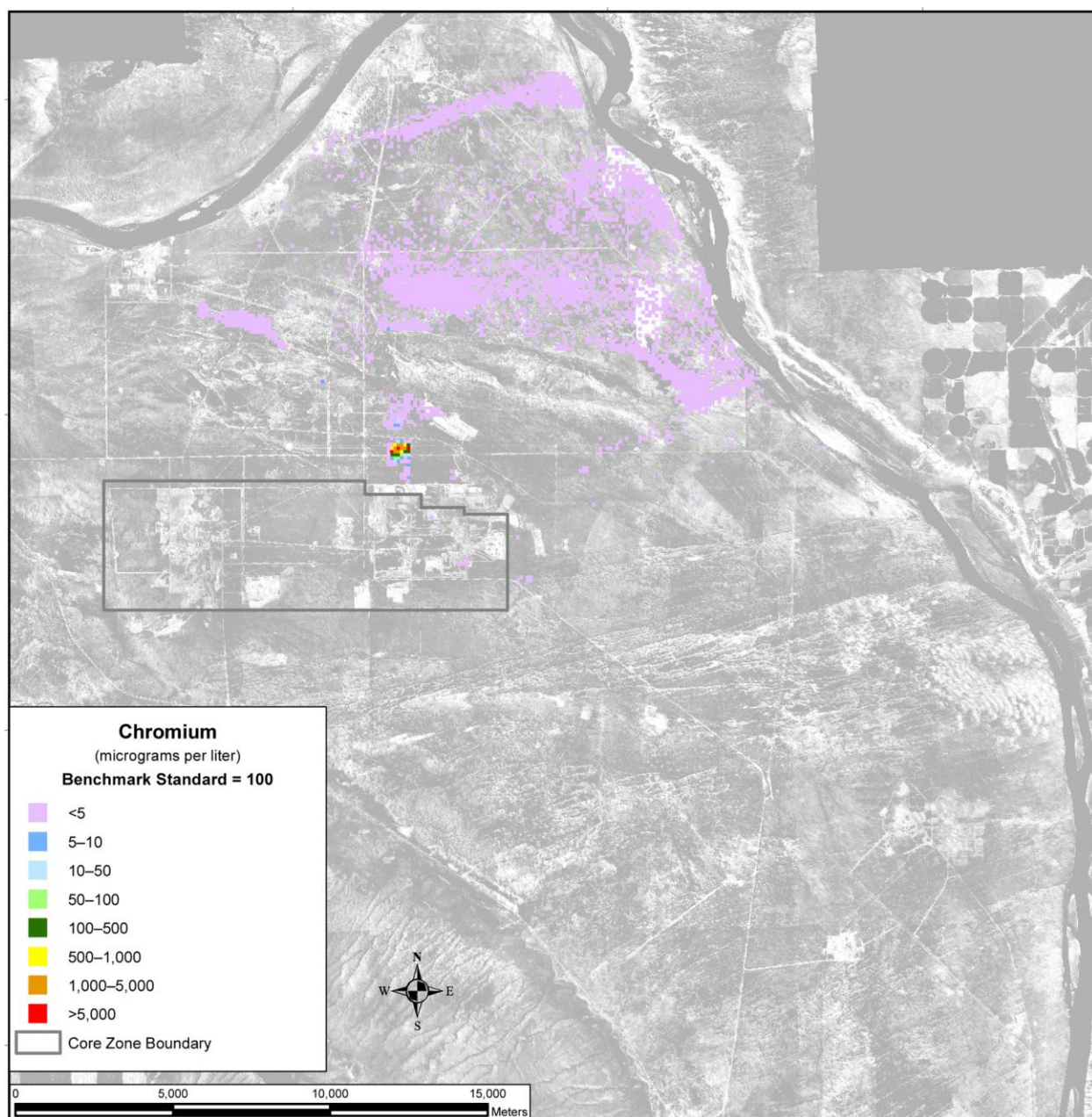
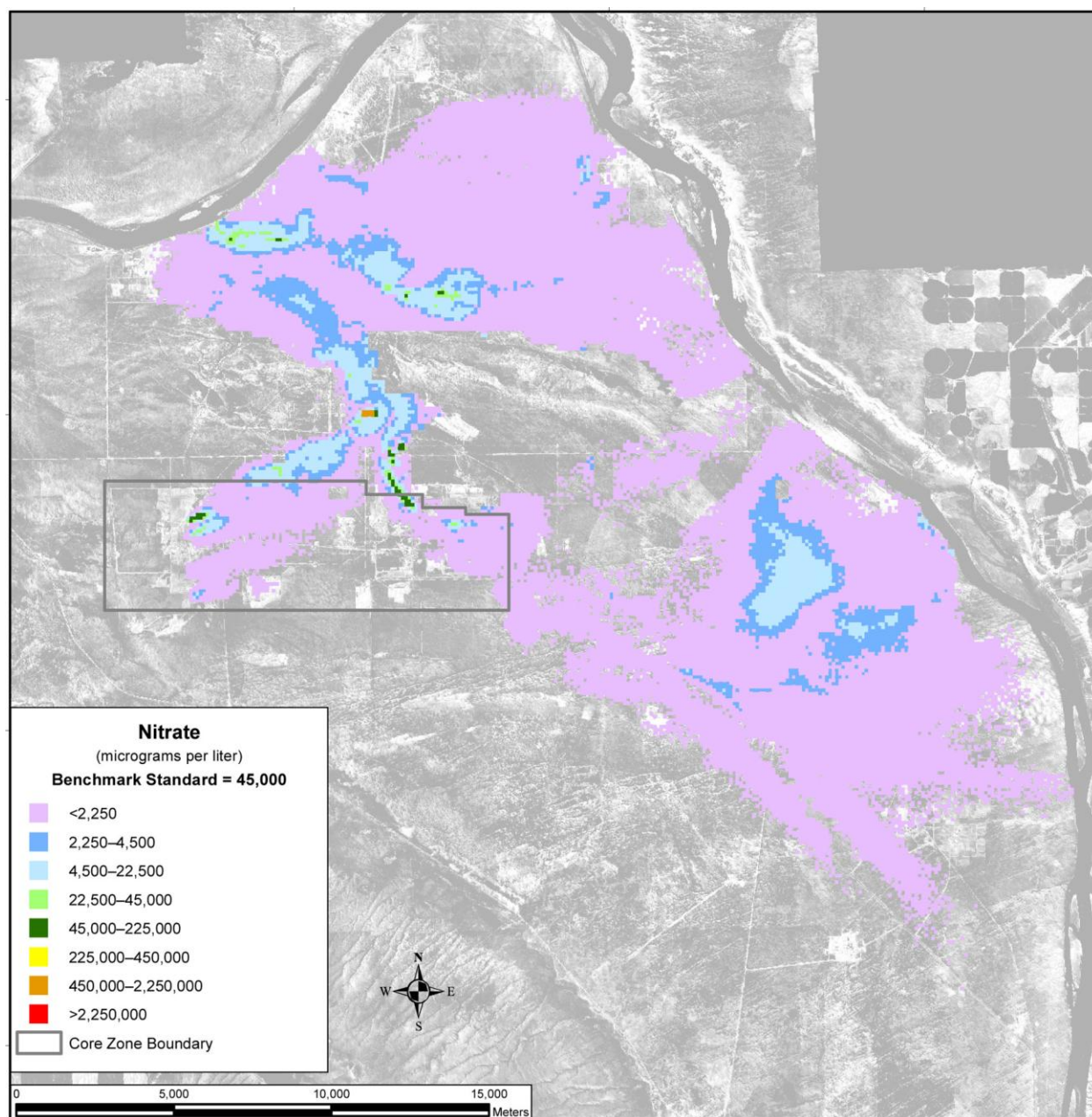
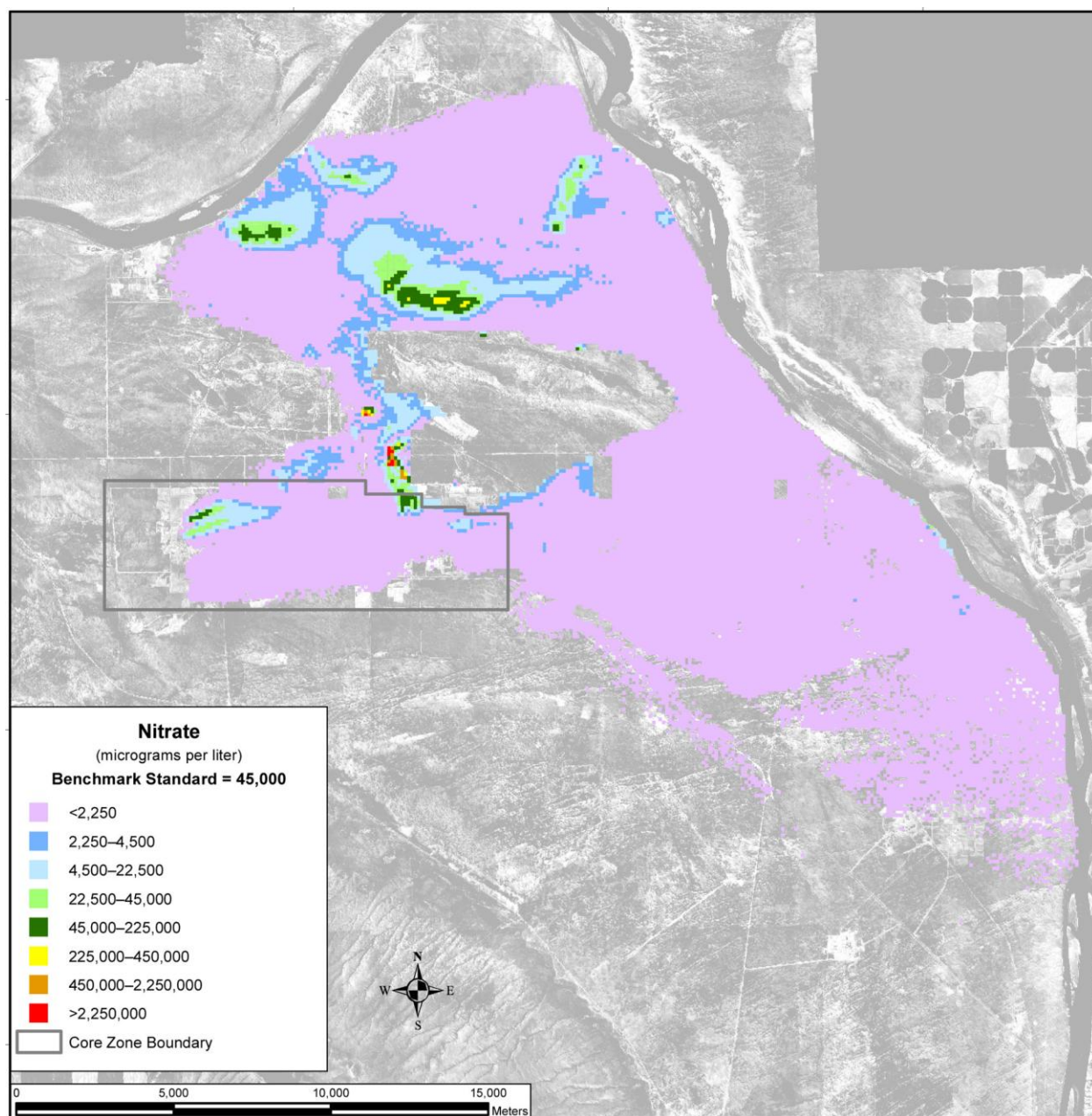


Figure 5-245. Tank Closure Alternative 6A, Option Case, Spatial Distribution of Groundwater Chromium Concentration, Calendar Year 7140



Note: To convert meters to feet, multiply by 3.281.

Figure 5–246. Tank Closure Alternative 6A, Option Case, Spatial Distribution of Groundwater Nitrate Concentration, Calendar Year 2010



Note: To convert meters to feet, multiply by 3.281.

Figure 5–247. Tank Closure Alternative 6A, Option Case, Spatial Distribution of Groundwater Nitrate Concentration, Calendar Year 2135

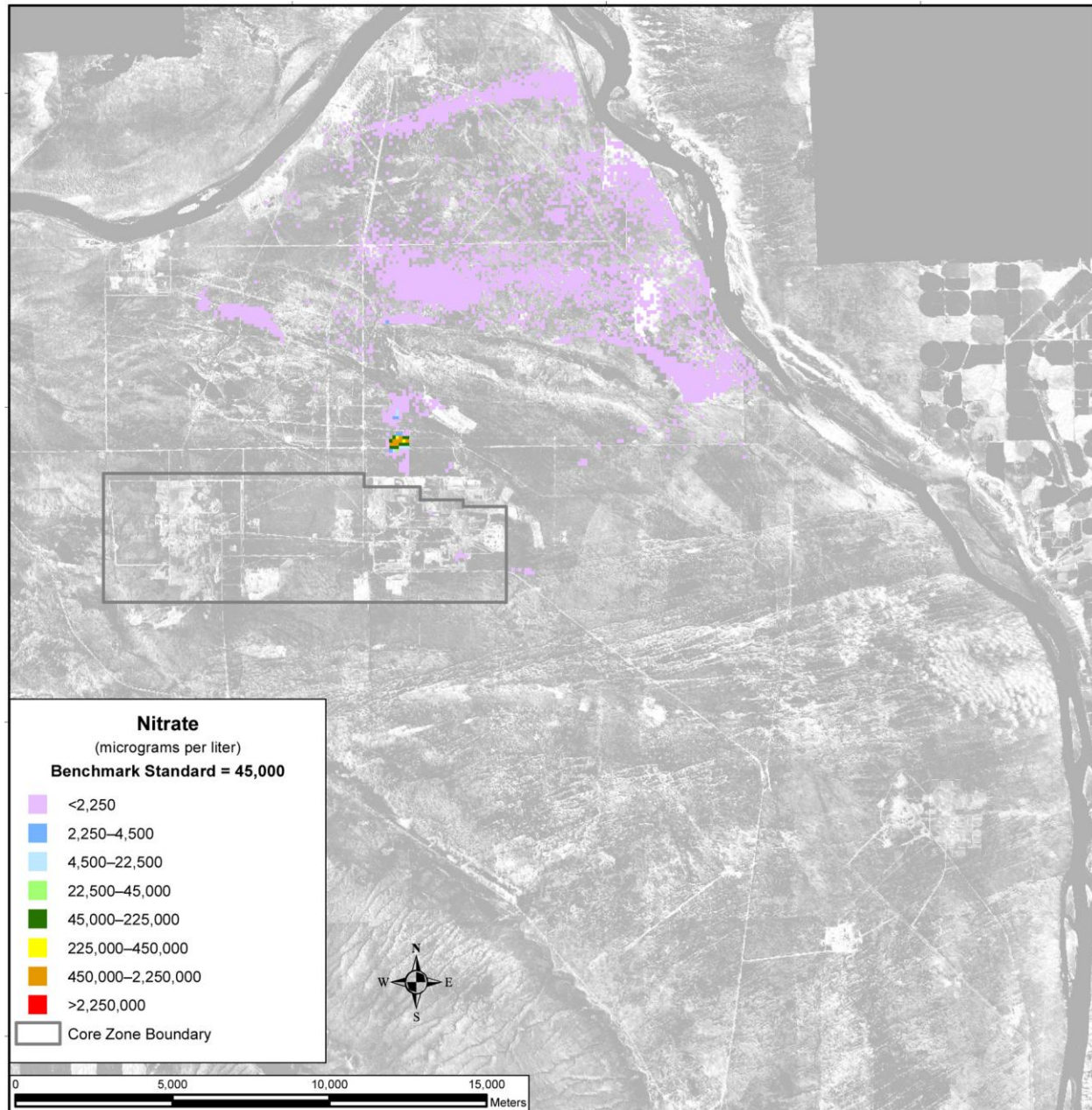


Figure 5–248. Tank Closure Alternative 6A, Option Case, Spatial Distribution of Groundwater Nitrate Concentration, Calendar Year 7140

Uranium-238 and total uranium under the Base Case are not as mobile as those COPCs discussed above, moving about seven times more slowly than the pore-water velocity. As a result, travel times through the vadose zone are longer, release to the aquifer is delayed, and travel times through the aquifer to the Columbia River are longer. Figure 5–249 shows the distribution of uranium-238 in CY 2010. There is a small plume associated with releases from cribs and trenches (ditches) and past leaks at the T Barrier that is less than one-twentieth of the benchmark concentration. This plume is seen extending northeast through Gable Gap. By CY 7140, the area of the plume has grown and extended to the Columbia River, but the plume is still significantly below the benchmark (see Figure 5–250). In CY 11,940, the greatest development of the plume during the analysis period is seen, although no areas exceed benchmark concentrations (see Figure 5–251).

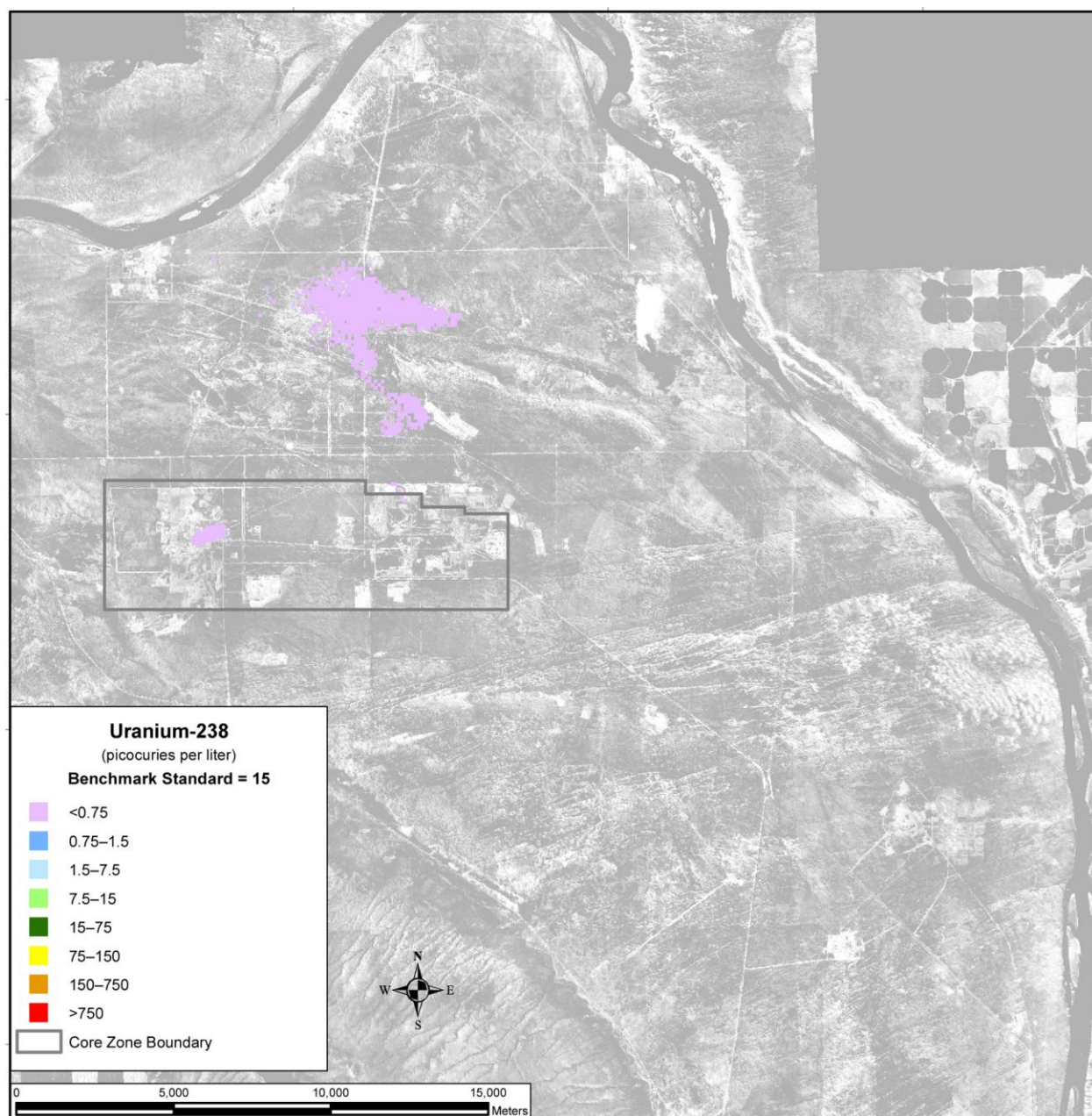
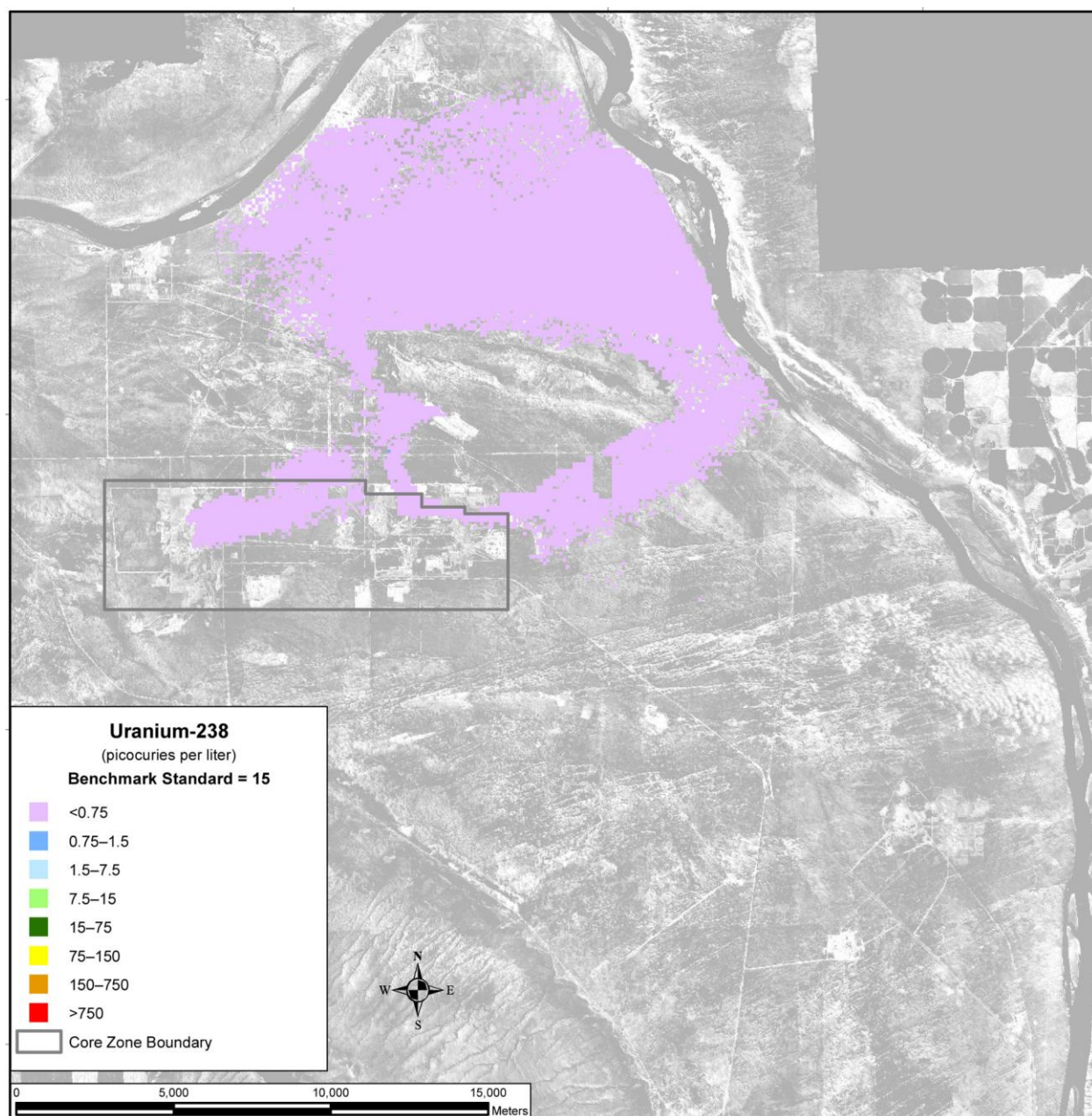


Figure 5–249. Tank Closure Alternative 6A, Base Case, Spatial Distribution of Groundwater Uranium-238 Concentration, Calendar Year 2010



Note: To convert meters to feet, multiply by 3.281.

Figure 5–250. Tank Closure Alternative 6A, Base Case, Spatial Distribution of Groundwater Uranium-238 Concentration, Calendar Year 7140

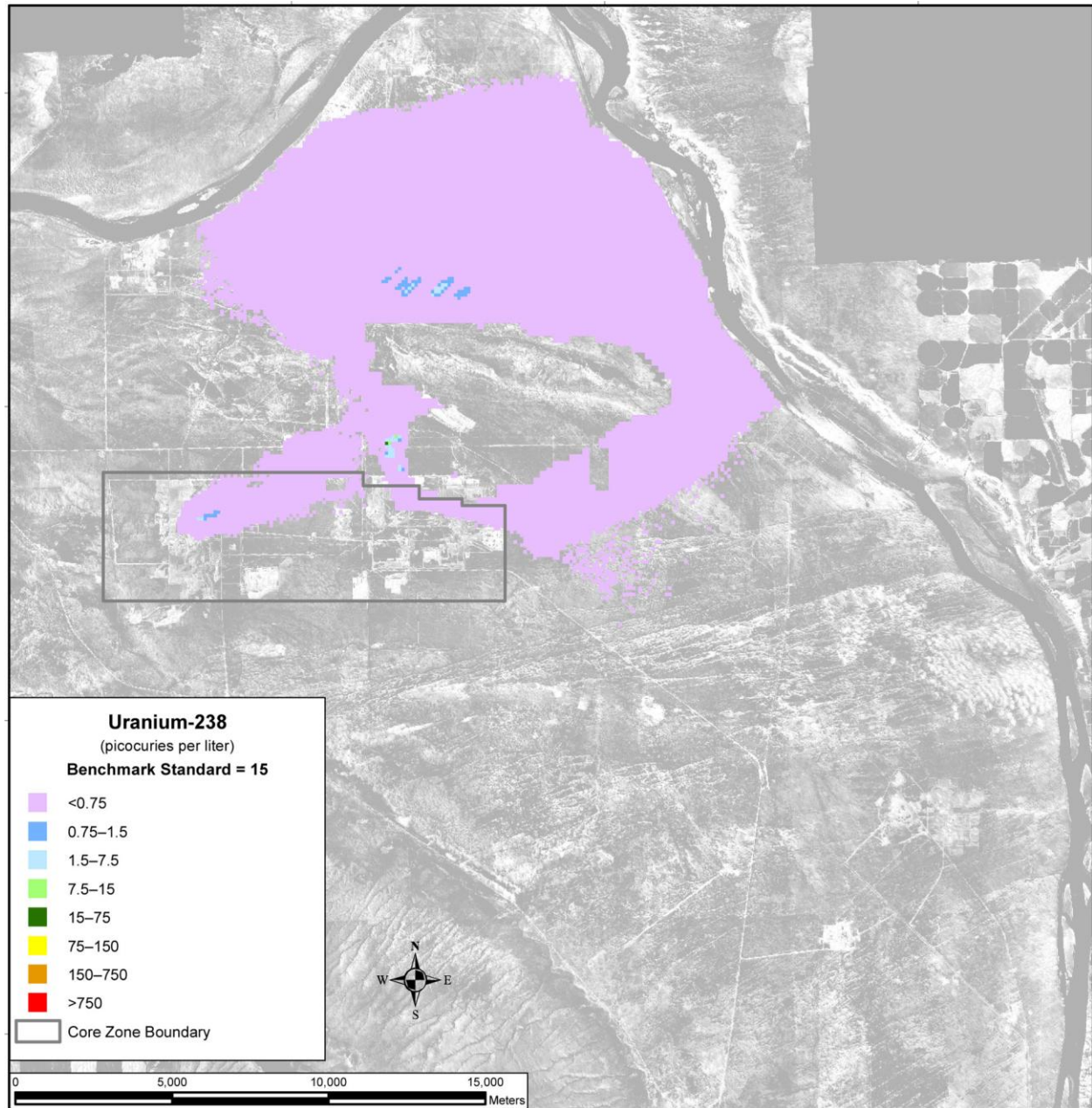


Figure 5–251. Tank Closure Alternative 6A, Base Case, Spatial Distribution of Groundwater Uranium-238 Concentration, Calendar Year 11,940

Figure 5–252 shows the distribution of uranium-238 in CY 2010 under the Option Case. There are two plumes associated with this case, one originating from the T Barrier and the other from the B Barrier. Although there are no significant contaminant concentrations, the plumes under the Option Case are larger than those under the Base Case. By CY 2135, the contaminant plumes have grown, but there are still no significant peaks in concentration levels (see Figure 5–253). By CY 11,940, the year in which the greatest development of the plumes occurs under the Base Case, the contaminant plumes under the Option Case have begun to recede (see Figure 5–254). This recession is due to the removal of the six sets of cribs and trenches (ditches) and the remediation of their contaminant plumes. Figures 5–255 through 5–257 show similar results for total uranium.